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Journal in v. 34.

Volume XXXV

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INDEX TO VOLUME XXXV

Abstract of Minutes of Board of Directors 45-98-151-199-248-304-358-407-446-486-525-556
Abstract of Minutes of Club 45-99-151-199-247-304-486-555
Abbott, Lyman, Dr. Address 328
Adams, Comfort A., Prof. Electric Welding Practice 531
Address. By Dr. Lyman Abbott 328
Address. By Carl C. Thomas 326
Address. By Samuel M. Vauclain 323
Address. By Charles T. Main 321
Address. By Hon. William Howard Taft 319
Address of the President, Major J. A. Vogleson 298
Allen, Arthur H. Compression Rheostats 187
America Seeing It Thru. By Hon. William Howard Taft 379
American Merchant Marine, The. By Lieut. Commander Stevenson Taylor 552
American Progress in Pharmaceutical Chemistry. By Robert P. Fischelis 39
Anderton J. H. Time Saving in Steel Ship Construction 467

Barth, Carl G. Income Tax, The—An Engineer's Analysis with Suggestions. Parts I and II .... 280 and 342

Cathcart, William L. War on Land and Sea, The 128
Chance, H. M. New Method for Separating Slate from Coal, A 369
Clement, Charles M., Major-General. Work and Experiences of the United States Engineer Troops in France, The 57
Coal Thrift—Suggestions Offered by the Committee on Fuel Conservation of the Engineers' Club of Philadelphia 144
Cole, E. L. Engineer and the Fuel Administration, The 444
Color in Illumination. By Beatrice Irwin 190
Comparison Between American and British Practice in Electric Welding. By Commander S. V. Goodall 493
Compression Rheostats. By Arthur H. Allen 187
Covered-Electrode Process, The. By E. G. Rigby 472
Concrete Ships. By L. R. Ferguson 90

Dobson, W. A. Early History of American Shipbuilding 455

Early History of American Shipbuilding, The. By W. A. Dobson 455
Electric Welding—A New Industry. By H. A. Hornor 537
Electric Welding Practice at the Submarine Boat Company's Plant. By Clark Henderson 499
Electric Welding Practice. By Prof. Comfort A. Adams 531
Electric Welding as Applied to Steel Ship Construction—Introduction by H. A. Hornor 427
Elements Affecting Riding Qualities of a Motor Vehicle—"Springs," The. By Walter C. Keys 33
Engineer in the Chemical Industry, The. By H. E. Hollister 37
Engineer and the Fuel Administration, The. By E. L. Cole 444
Engineering as a Force in Philadelphia's Progress. By J. Franklin Stevens 519

Ferguson, L. R. Concrete Ships 90
Fernald, R. H. Is Our Fuel Supply Nearing Exhaustion? 176
Fischelis, Robert P. American Progress in Pharmaceutical Chemistry 39
Flinn, Alfred D. New York City's Catskill Mountain Water Supply 111
Forster, H. W. Industrial Housing 18

Garrett, W. A., Major. Some of My Observations in France 217
Gill, John D. War Status of Gasoline and Fuel Oil 417
Goodall, S. V., Commander. Comparison Between American and British Practice in Electric Welding 493

Heavy Oil Engine, The. By Charles E. Lucke 269
Henderson, Clark. Electric Welding Practice at the Submarine Boat Company's Plant 499
Hering, Carl. The Much-Abused Term "Mass" in Engineering Calculations 240
Hering, Carl. Text Book vs. Practice 482
Historical Lighting of Independence Square, Philadelphia, The. By E. F. Kingsbury 65
Hogg, Albert N. Reconstruction in Philadelphia After the War 553
Hollister, H. E. Engineer in the Chemical Industry, The 37
Horning, Harry L. Impressions of the Great War 333
Hornor, H. A. Introduction—Electric Welding as Applied to Steel Ship Construction 427
Hornor, H. A. Electric Welding—A New Industry 537

Income Tax, The—An Engineer's Analysis with Suggestions. By Carl G. Barth. Part I 280
Income Tax, The—An Engineer's Analysis with Suggestions. By Carl G. Barth. Part II 342
Industrial Housing. By H. W. Forster 18
Influence of Topography Upon the Strategy of the European War, The. By Frederick K. Morris 223
Inventions Relative to War Material. By Capt. W. Strother Smith 3
Impressions of the Great War. By Harry L. Horning 333
Irwin, Beatrice. Color in Illumination 190
Is Our Fuel Supply Nearing Exhaustion? By R. H. Fernald 176

Johnson, Wm. F. Standardizing Methods of a Modern Utility 14

Keys, Walter C. Elements Affecting Riding Qualities of a Motor Vehicle—"Springs" 33
Kingsbury, E. F. Historical Lighting of Independence Square, Philadelphia, The 65
Knapp, I. N. Optimistic View of the Future Supply of Oil, An 22
Knox, H. G., Naval Constructor. Nomenclature for Electric Welding 428

APR 15 1919 461531

Labor and Capital. By Harry Tipper ... 425
Ledoux, John W. Plant Extensions of Public Utilities Financially Considered ... 337
Lighting Curtailment. By Preston S. Millar ... 381
Lindemuth, L. B. Metallurgy of Electric Furnace Steel Processes, The ... 544
Lowell, A. Lawrence. Safeguarding the Future ... 483
Lucke, Charles E. Heavy Oil Engine, The ... 269
Ludlam, David S. Recent Observations in France ... 330

MacElwee, E. S. Ports and Terminal Facilities ... 165
Main, Charles T. Address ... 321
Manufacturing in Relation to Banking, Research and Management. By Walter Rautenstrauch ... 81
Manufacture of Ordnance Forgings. By George Satterthwaite ... 502
Marburg, Edgar—In Memoriam ... 405
Members of Engineers' Club in Service in the Army or Navy of the United States, as of November 25, 1918 ... 558
Merrill, W. L. Tools for Electric Welding ... 436
Metallurgy of Electric Furnace Steel Processes, The. By L. B. Lindemuth ... 544
Millar, Preston S. Lighting Curtailment ... 381
Morey, George W. Solubility and Fusion Relations at High Temperatures and Pressures ... 509
Morris, Frederick K. Influence of Topography Upon the Strategy of the European War ... 223
Much-Abused Term "Mass" in Engineering Calculations. By Carl Hering ... 240
My Experiences at the Front. By Corporal Frank Street ... 235

Necrology—Edgar Marburg ... 405
New Method for Separating Slate from Coal. By H. M. Chance ... 369
New York City's Catskill Mountain Water Supply. By Alfred D. Flinn ... 111
Nomenclature for Electric Welding. By Naval Constructor H. G. Knox ... 428
Notes on Fire Prevention. By H. P. Weaver ... 192

Offensive Against the Submarine. By Joseph A. Steinmetz ... 69
Optimistic View of the Future Supply of Oil, An. By I. N. Knapp ... 22
Outerbridge, Alexander E., Jr. Safety First for Foundrymen ... 300

Plant Extensions of Public Utilities Financially Considered. By John W. Ledoux ... 337
Port of Philadelphia, The. By George S. Webster ... 549
Ports and Terminal Facilities. By R. S. MacElwee ... 165

Radium and Radio-Activity. By Charles H. Viol ... 346
Rautenstrauch, Walter. Manufacturing in Relation to Banking, Research and Management ... 81
Recent Observations in France. By David S. Ludlam ... 330
Reconstruction in Philadelphia After the War. By Albert N. Hogg ... 553
Relation of Light to Health, The. By Charles E. de M. Sajous ... 440
Report of the Tenth National Conference on City Planning, St. Louis, Mo., May 27-29, 1918. By Joseph C. Wagner ... 339
Rigby, E. G. Covered-Electrode Process, The ... 472
Roadefer, L. M. Training Children in Safety ... 520

Safeguarding the Future. By A. Lawrence Lowell ... 483
Safety First for Foundrymen. By Alexander E. Outerbridge, Jr. ... 300
Sajous, Charles E. de M. Relation of Light to Health, The ... 440
Satterthwaite, George. Manufacture of Ordnance Forgings, The ... 502
Smith, W. Strother, Captain. Inventions Relative to War Material ... 3
Solubility and Fusion Relations at High Temperatures and Pressures. By George W. Morey ... 509
Some Fundamentals of Aviation. By William B. Stout ... 335
Some of My Observations in France. By Major W. A. Garrett ... 217
Standardizing Methods of a Modern Utility. By Wm. F. Johnson ... 14
Steinmetz, Joseph A. Offensive Against the Submarine ... 69
Stevens, J. Franklin. Engineering as a Force in Philadelphia's Progress ... 519
Stout, William B. Some Fundamentals of Aviation ... 335
Street, Frank, Corporal. My Experiences at the Front ... 235
Stuart, Charles E. War Conservation of Power and Light ... 400

Taft, William Howard, Hon. Address ... 319
Taft, William Howard, Hon. America Seeing it Thru ... 379
Taylor, Stevenson, Lieut. Commander. American Merchant Marine, The ... 552
Text Book vs. Practice. By Carl Hering ... 482
Thomas, Carl C. Address ... 326
Time Saving in Steel Ship Construction. By J. H. Anderton ... 467
Tipper, Harry. Labor and Capital ... 425
Tools for Electric Welding. By W. L. Merrill ... 436
Training Children in Safety. By L. M. Roadefer ... 520

Vauclain, Samuel M. Address ... 323
Viol, Charles H. Radium and Radio-Activity ... 346
Vogleson, J. A., Major. Presidential Address ... 298

Wagner, Joseph C. Report of the Tenth National Conference on City Planning, St. Louis, Mo., May 27-29, 1918 ... 339
Wardrop, G. Douglas. War in the Air, The ... 9
War Conservation of Power and Light. By Charles E. Stuart ... 400
War in the Air, The. By G. Douglas Wardrop ... 9
War on Land and Sea, The. By William L. Cathcart ... 128
War Status of Gasoline and Fuel Oil. By John D. Gill ... 417
Weaver, H. P. Notes on Fire Prevention ... 192
Webster, George S. Port of Philadelphia, The ... 549
Work and Experiences of the United States Engineer Troops in France, The. By Major-General Charles M. Clement ... 57

PRESS OF J. B. LIPPINCOTT COMPANY PHILADELPHIA

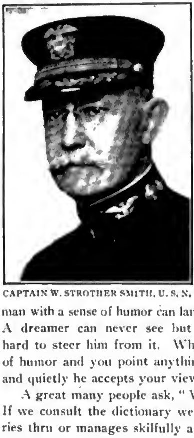
THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-1 JANUARY, 1918 NO. 158

INVENTIONS RELATIVE TO WAR MATERIAL*

By CAPTAIN W. STROTHER SMITH, U. S. N.

IT is a very great pleasure to me this evening to come and address you. Not accustomed to public lecturing, looking at this audience I am reminded of the big Irishman who was on a ship, caught in a typhoon on the China Sea, some years ago. During the storm the foretopgallant mast was carried away, and just as the officer of the forecastle got forward he saw a great six-foot Irishman praying, "Just save me this time and I'll never go to sea again."



CAPTAIN W. STROTHER SMITH, U. S. N.

A strong sense of humor is one of the finest things in the world. Very often it shows the difference between the practical inventor and the enthusiastic dreamer. A man with a sense of humor can laugh at his own mistakes. A dreamer can never see but one point, and it is hard to steer him from it. When a man has a sense of humor and you point anything out to him politely and quietly he accepts your view.

A great many people ask, "What is an engineer?" If we consult the dictionary we read, "One who carries thru or manages skilfully a project or scheme by contrivance and effort." And then follows the manufacturer—and what is his endeavor? "To fashion into useful or desirable form." The engineer manages skilfully and the manufacturer makes something desirable. We want nothing else. In the application of inventions, do not start anything that is going to take years to develop. A man will say, "I have the most wonderful machine in the world." He is asked, "What can you do with it?" He replies, "Well, here is a torpedo. We can make this torpedo so that it will go out and do unheard-of things. We start this torpedo and it will go away over yonder and follow a ship around in circles and it is bound to hit it—can't get away from it." He is then asked, "How do you make it?" And he replies, "Well, of course, you have the torpedo, and what I'll do is to put ears on it and make it go straight out to them." I then explain to him that in order to do that it would be necessary to change the whole design of the torpedo; that a torpedo is the development of years of study, and just in order to put that little thing on the torpedo we would have to start from where we first began and build the torpedo up to his ideas.

There is nothing new under the sun. We have oft repeated it, and any one of you can fully understand that when you have worked on an idea in engineering or manufacturing little by little, and then look back on the thing that you manufactured ten or twenty years ago, you can pick out the different steps of improvement until it has gotten up to what it is now and you will recognize it as the same thing; yet, if some one tells you that you can to-day manufacture something twice as good as that, you laugh at him and say it cannot be done. If you want anything worked out the best way, go into your establishment and pick out your best men, put them on it, give them a free hand, and say, "Go to it. If you want advice, if you want help, come to me." And that is what this whole country of ours must realize. We must sink any personal ambition, and if you feel that there is a right man at any work, let him do it. Say, "Go to it." Cheer him on; help him out.

Another principle: In developing any new idea or invention, round it out into form and put it into practice. Do not change it every day. Do as the automobile manufacturer does; get out a new model when the time comes, and then you will have the new form in practical and completed shape to manufacture and put upon the market. If a man had to run a new car every day he would never feel that sense of enjoyment that comes with the wearing of a well-broken shoe.

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*Presented at Joint Meeting of Engineers' Club and Manufacturers' Club, December 10, 1917.

A great many men come along with dreams—ideas not worked out. One of them came to a member of the Board and said, "Why don't we electrocute the German submarine?" "Why," we said, "we would be very glad indeed to have you tell us your method of doing this." "Oh," he said, "I have given you the idea. You are an engineer. You work it out."

Another has dreams of projecting wireless waves out over the country—electrocute everything; put them to sleep by wireless waves. He does not tell us how—he has not gotten so far; but he will divulge it if you will send somebody to him and tell nobody else about it.

Some come with flying devices. "Wouldn't it be a wonderful thing if we could just simply fly a devil torpedo from here over yonder?" "It certainly would be if you could do it; but how?" "Well, just build an aeroplane, put some bombs on it, put a watch or clock on it, start it off and let it go." "Now, suppose you have a wind blowing thirty miles an hour toward you, where would it go in an hour?" "Or, suppose you had a wind going at the rate of thirty miles an hour away from you, at the end of an hour your aeroplane, if it traveled fifty miles an hour, would be within a circle whose radius would be thirty miles and fifty miles away. That is a pretty big target to hit."

How are we to enlist the services of an engineer? A good many years ago I was invited to be a silent witness of a test. One side was represented by a man who was a very plausible and charming man—a college graduate, but without much experience in that particular branch of engineering on which he was undertaking to pass judgment. The other side had a man that knew how to do certain things, but he did not know how to argue against the first. When they conferred, the man who talked the best downed the other, and the result was one of the most ridiculous reports that I have ever read. The man who invited me said to me, "Well, we don't seem to have gotten very far? No satisfaction or real settlement. What do you think? What would you advise me to do?" I replied, "Why don't you get an engineer? Get some man who knows the job that you are after."

Do not expect one who knows all about planting a farm to tell you about the sea; and do not ask a sailor to be a farmer. I tried once. I sowed some cantaloupe seeds. The rule said, "Put them in a hill 14 inches high." I put the seeds on the ground and built a 14-inch hill above it. Some time afterward I sent for an old darky and I said, "Sam, why don't these seeds grow?" And he said, "How did you plant them?" I told him, and he replied, "Captain, they may come up next year, but there's one thing certain: they won't come up this year."

There is one thing that requires great care. It is very difficult to give information that would be really helpful. So much is confidential, and one can very easily understand that this must be kept in the hands of a very few It is not that people are not to be trusted, but there are some who would like so much to get it that it is much the safest thing to keep it in the hands of the smallest number. Information is given to well-known engineers and scientists who have really produced valuable devices. So many write and say, "I have received no answer," without waiting a reasonable length of time. One man wrote on the 10th of the month and then wrote on the 13th. If he received a reply in a month sometimes he is doing well. Last May and June letters, suggestions, and ideas were coming in at the rate of five hundred to seven hundred a day, faster than any number of people could read them. To-day letters are being answered within two or three days—acknowledged within one day; and those presenting ideas that are well known or not of value are informed within a very short time. The cases that require further investigation sometimes take four or five weeks. If any real patriotic citizen, who earnestly wants to help, presents an idea, good or bad, there is absolutely no trouble whatever in getting beyond the clerks or the rubber stamp that so many suspect.

If all engineers were to resolve themselves into what is on board ship the ward-room mess, we would get along finely. The ward-room mess is composed of a large number of officers, just as democratic as they possibly can be; at the same time recognizing military authority, but there is no one of them, not even the youngest, who does not feel that he can propose anything that he wants to propose. He gets the best criticism in the world: good-natured criticism. He either goes forward or is stopped right there.

So many people come and show things who, if they had gone to almost any man based in the fundamental principles of engineering, would have saved themselves a great deal of trouble. All men with good engineering knowledge will encourage discussion. Let it be known in communities that if a fellow-citizen has an idea he can come to his fellows and get at least some aid and help. That is where you can help—help wonderfully—help to keep the forty thousand inventions from coming to Washington, except in good shape. A large number of them have some little defect that can easily be pointed out and straightened out.

In reducing inventions to practical engineering conditions, Admiral Sims says, "Make them so the ordinary, everyday sailorman can use them—not laboratory instruments or anything of that kind. Make them simple. Cut out every automatic device." The hand of a man is the finest automatic device in the world, and if I were not afraid of offending the sentimentalists thruout this country, I would say it is the cheapest thing in time of war. No man or officer appreciates anything on earth so much as the chance to do what he has to do. If a man is killed, another man is always ready to take his place as quietly as changing partners in a ball-room. Never on board ship is there any station or job but that there are a number of men available who can easily fill it. Every station has at least three or four men; and so is always manned. And you can repair a man much quicker—or replace him much quicker—than any automatic device that you have ever known. Of course, those automatic devices are fixed so that they can be thrown out, but sometimes they get jammed, and always at the crucial moment.

Very frequently, when an objection to a device is pointed out to the man who has offered it, he will say, "Oh, yes; I have overcome that; I have added this." Then, still to overcome that, there is another one. "Well, you see, I get around that by putting something here." You have to go thru straight to the point and shove all aside to get down to the simple thing you want.

A modern battleship is the result of years of study and evolution—just as any other machine that you may invent and that the engineer or manufacturer puts on the market. It takes a great deal to develop it and a great deal to put it out of action. Two torpedoes will not, and in some cases three have not done it. We know of a modern battleship that after being three times torpedoed went into port at fifteen knots.

A good many devices show considerable ingenuity and original thought by men who read deeply on all subjects concerning the war. A large percentage of them are along lines already covered. There are some who write back and say, "I don't think you looked at my invention carefully, and I should like to have the parts pointed out to me wherein it failed." That is absolutely impossible with ninety-nine per cent. of them. If you did that it would require more experts giving their entire time than the Navy Department possesses.

The usual method is to divide any invention into ten parts. The inventor comes with one. If he cannot harmonize with the other nine his invention is not worth very much.

Comparing engineering talent thruout the world, we are not behind in talent—in some things we go in too much for production and too little for fine workmanship. When we built the Liberty motor we got together the finest internal-combustion automobile engineers in this country—those we knew were good—and the Liberty motor is a combination of the finest points and is a remarkably fine piece of workmanship. One great trouble we have had for a number of years is steel castings. We could buy all the 70,000 or 100,000-pound steel castings we wanted—no difficulty whatever. If you go to a steel foundryman and say, "I want 100 20-ton steel castings," he will say, "Certainly; give them to you to-morrow; take the order right away." But if you go to him and tell him you want a thousand fine steel castings weighing fifty pounds apiece, he says, "I don't know about that; I don't think I can take that order; I couldn't satisfy you."

All shops can fill up with castings comparatively simple to make. The man who can make them does so. It is perfectly natural to be content with that: nobody can expect anything else.

The Germans like to compare engineering talent. When the *Deutschland* came over their representative went to an engine-building company and said, "We would like very much to have some of our people look thru your ship," and the shrewd reply was, "We would be delighted to exchange courtesies with you; we will send our men down to the *Deutschland.*" They never heard anything more from him. The Germans succeed principally in doing splendid small, fine work; they build wonderful submarine engines, because they do fine detail work.

A good many years ago, while in Philadelphia inspecting some castings, I found the foreman of the foundry, a Belgian, who showed me some very small steel castings. He could hardly speak English. "Why," I said, "do you mean to say that you know how to make those?" He replied, "Yes, in Belgium we have made them for some years." They were cast-steel cups without a flaw in them. There has been little call for such in this country, but there is bound to be now, and until we do get things of that kind we are not going to do as fine work as the Germans. We have got to realize that.

Engineering talent has not been of as fast growth in this country as we would like to see it, but it is coming all right, and is about here now. We have to get over the idea as exemplified in the story of old Jim. Some years ago, when a number of engineering graduates of the Naval Academy went out to civil life, one went out West and got a job, and one day the president of the firm came in and said, "Boys, we will have to shut down the shop. I am sorry, because we are filled up with work, but Jim is sick, and I don't know how we are going to run the engine." And this young graduate turned to the president and said, "Did I understand you to say that you cannot run the engine? Why, I can run the engine." The president replied, "Do you mean to say that you can run an engine?" He said, "Certainly I can." "Well," said the president, "if somebody cannot run that engine the work has to stop." "Well," said the young man, "try me." Monday morning he went down to run the engine that week. Before Friday he found out that the engine was full of faults. So, wanting to help out his firm, he went down Sunday, stripped off his coat, set the valves, adjusted the bearings, looked all over the engine, and next week he offered to show the president of the firm how he could save twenty-five per cent. of the coal bill. The president was rather doubtful of it, but he went down and saw that there was actually saved at least twenty-five per cent. of the cost of fuel for the week. After the end of another week Jim came back. He went in to the president and said, "Somebody has been fooling with my engine." "What's the matter, Jim?" "Well, somebody has been down here since I have been gone and fooled with that engine." The president said, "What are you going to do, Jim?" "Why, I am going to fix her the way she was." And he did. He went back to the old way of running it, and they paid the coal bill.

That is not done to-day. There is no successful manufacturer to-day who questions the ability of the skilled engineer. If there is anyone who says that manufacturers are not successful, all he has to do is to look at this magnificent building. The manufacturer is or has an engineer; and he does not put up with old practices. That is why I say the engineering talent to-day is where it ought to be.

The needs of the Navy will be met—little by little—just exactly like any other manufactured articles, and with little improvements. There is no grand, brilliant invention that is going to win this war. The Navy recognizes the value of engineers and recognizes the value of those who have been engaged in absolutely practical work. Recently the call went out for one hundred electrical engineers. The Naval Consulting Board, the American Institute of Electrical Engineers, and the National Research Council were each asked for nominations, and out of two hundred and fifty, one hundred were selected, and on the list of the one hundred will be found men who are giving up $10,000 a year to take $2000 positions in the Navy. Is not that fine? The question was, "If selected, will you serve?" Not one refused. Splendid men!

The American engineer can adapt himself better than any other that I have ever known anywhere, and I have known some all over the world. Kipling tells a very good story of the Boer War. There was a young subaltern who came out from London to South Africa, and he was placed under a colonel who had done a great deal of campaigning and knew men thoroly. This young subaltern saw what he supposed to be a lot of privates building a bridge, but they were American engineers, getting anywhere from $40,000 to $20,000 a year and doing a bit of adaptation to circumstances. The Irish sergeant tells the story of how this young subaltern interfered. The sergeant told his mate about what the colonel said to this subaltern when he heard of it. He said, "I've seen the Dook pass the time of day to a company of 'Orse that went wrong, but this was 'Lord love him for his mother' to what the colonel said to the subaltern."

The engineer and the manufacturer have grown up together. A great many years ago the manufacturer who had good, steady work and very keen foresight sent his son to college, made him an engineer, and put him back to the manufacturing business. You have to-day a manufacturer who is really an engineer.

The link between the manufacturers and the needs of the Navy: We want refinement in workmanship in war material, because we are not near the base. It has to go away off yonder some place and fit. It cannot be sent back to have a little cut taken off.

They want prompt delivery. That may be the fault, in peace times, of the Government, because red tape is not sufficiently cut. We all know that and all recognize it, but we are trying to cut red tape to-day, and it is being done. I have seen a battleship held up for two little pieces of silver worth about two dollars, after all orders had been in for some time. That is pretty bad business management, but that could be cut out nicely by all people getting together, and it can be stopped.

They want correctness of spare parts If you have been off miles to sea with something broken down and you had a well-fitted spare part, you have no idea what a perfectly fine, comfortable feeling there is. I knew an officer some years ago who used to sit in the wardroom and play cribbage a great deal, and they tell this story of him. One day one of his men came to him and said, "One of the boilers is blown out." He said, "Don't bother me about that; put on another." Later they told him that the starboard evaporator leaked. "Put on the port," he said. Then they said, "The ice machine is stopped." "Let me go out there at once. Only one ice machine."

There is one thing we are coming to—and it would have been a fine thing if we had come to it a little sooner, not only for the Navy but everywhere else—and that is the use of gauges—plenty of them—so that they do not wear out: nothing so ensures the accuracy of spare parts.

One of the finest things that all of you can do is to infuse patriotism in your employes. Nothing on earth ever made me feel so good or made me feel so proud that I had spent three years here in the Philadelphia Navy Yard as to know that when there was talk of dissatisfaction, the men of the yard came down to Secretary Daniels and said, "Mr. Secretary, you can count on us." There is nothing finer than that. I know those men. I have spent three years with them. It is that spirit that should go all thru this country. If all the manufacturers and engineers in this country employing men would only go among them and tell them, "You are not doing this for a dollar or for your day's pay. Every little cut you take on this machine, in every way that you help, in everything that you are turning out, you are doing just as much fine work as the man firing a gun in the trenches, every bit!" Get that thing right straight thru every man you know; get it all over the country. You may talk about German money coming here to make our men discontented, but you would stop that quicker than lightning if you got that spirit thru the people. There is no more patriotic country in the world than America. Just let them know that our enemies are telling us that we cannot do certain things that we regard as our birthright.

In the Revolutionary War they went to the mountaineers back of the Allegheny and Blue Ridge range. Those men did not care for England or for anything else. They were perfectly satisfied to live in peace in the mountains. They were brought in the war because they went to them and said, "Look here: King George of England said you sha'n't drink tea." And they said, "He does, does he?" Their rights were interfered with, and that is what put them into the war. So I say to you, go out and tell the people all over this country that we cannot have the freedom of the seas. Tell them that our women and children cannot travel this world in comfort and safety, and tell them that our particular liberties are being trodden on. That is the way to reach them.

There is hardly a manufactured article made to-day that does not enter into the needs of the war, and anyone that works can help.

Relating some of my few personal experiences, I received a letter just the other day in which was written, "In an endeavor to introduce myself to the Government as the most useful man in the world, I am having the time of my life." He wrote ten pages, telling us what a good time he was having, and then said, "I have a very wonderful flying machine. If you want to know about it, write me." I've worn out three or four pairs of glasses reading letters of that kind. Another man said, "I want a million dollars for my idea." He said, "Don't worry about it at all; the Treasury Department down there can print enough money while you are reading this letter to pay me."

One man facetiously wrote to a member of the Consulting Board, and picked out the wrong man, because he picked out a man with a very dry sense of humor. He commenced with, "Perhaps you receive a large number of ridiculous and foolish ideas. Maybe this one is one of the chief ones among them." And he received a very prompt answer, informing him that he was correct in both his premises.

I had the temerity to write an article last spring, and among the letters I received was one from a man who said, "I sent in my views about six months ago, and since I have sent them I have read your article and I am particularly impressed with the last paragraph, in which it was suggested that the ridiculous proposition of to-day may be seriously considered to-morrow and the day after prove the safeguard of the nation." That was a little journalistic touch I thought I would end with. He said, "I am submitting my idea now again to you on the strength of that last paragraph." I sent it back with the reply, "My dear sir: I am very glad to read your letter and appreciate the compliment, but your idea is still the ridiculous proposition of to-day."

A great many inventors quote the old proverb that "Necessity is the mother of invention." That is true; but she has some queer sons. One is the patriotic son: he is all right. A very large percentage of ideas are sent in by people who have a very earnest sense of patriotism—who have no idea whatever of personal gain or notoriety or anything but a real, earnest desire to help the Government, and they get all the attention that it is possible to give them. They also get sincere thanks—really sincere thanks. There are a few who write in for notoriety, and it sticks out all over, too. Some write in for pecuniary gain, and value their inventions anywhere from $100,000,000 down. I do not know any of this class that has come down to less than $50,000. They remind me, a good many of them, of a gentleman I once knew. He said that a friend of his had become broad minded, very broad minded; he is a very large man; you would hardly know him. "Why, he said, $50.00 is nothing to him" "Just half a hundred."

If every man in sending in a proposition would come down to a thoroly concrete principle and not waste time saying he is the son of somebody who fought in the Revolutionary War, or telling his family history, but just state what he has, it would save valuable time. If the idea is good, it stands for itself, and if it is not, it gets the same attention and a reply of thanks. If it is necessary to inquire into a man's good will, or whether he is patriotic, or whether he wants information, it is perfectly wonderful how quickly you can find out. There is no question that a good many persons send letters asking questions, and very leading questions, for confidential information, in the hope that somebody will tell them something. Sometimes it is apparent. I had occasion to investigate a man who was asking rather pertinent questions. I was informed in ten minutes of his whole history. I concluded I had better tell nothing. It is perfectly wonderful how extremely efficient is our Secret Service. A great many people have an idea that we are easy going.

One of the finest letters received was from a man who took a clipping from a magazine, giving an illustration of the periscope of a submarine traveling thru the water. He sketched a little appliance on it and said, "Is the idea as illustrated herewith of any value?" That is all he wrote. I was so pleased with his brevity and so flattered that he gave me credit for knowing exactly what he meant that I wrote him a full letter of thanks and appreciation.

It is the hardest thing to do, when a man sends you the product of his brain, perhaps of years, to tell him it is absolutely useless. It is almost like slapping him in the face. A great many people who come in have worked on their ideas a good many years, and some of them have come from long distances to Washington. It is the easiest thing on earth to tell them to go and get a patent, but that is not honest; that is not the ethics of an engineer. No engineer would back me up on that. Yet, at the same time, I have to sit down and crush that man's hopes, because it is right to tell him, as an officer of the Government, not only that we do not want it, but to save him any further expenditure of money. One man told me he had spent $16,000 in developing or working on an idea that any one of us could have told him in five minutes was not worth knowing. It was fundamentally wrong.

Now that is what I want the engineers of this country to help in. I want the ethics of the profession so great that it will save the people who cannot afford to spend the money on things of no value, and to give credit and encouragement for the things that are good. These men who spend their time, a great many of them, will realize it if told kindly, and be all the better citizens for it. Let it be a duty that we all owe our country to do that—especially now.

The English scientists who came over here said they received about a thousand letters for every casualty. When the *Antilles* was sunk we had immediately an increase of from fifty to one hundred a day. After this very sad catastrophe we will have several hundred more, each telling if we had used his device it would not have happened. The English said that the worst enemies they had to-day were the enthusiasts and fools, and of the two, the fools were the more honest.

One man came in with a device for a submarine, absolutely confident that it was the finest thing that had been presented. He was a good seaman and a man of a great deal of intelligence. The simplest way to talk to him was the common-sense way. "Now, I'll play the submarine with you. I will be the German submarine and you will be the American, with your idea. We will divide up, first into visibility, maneuvering, speed submerged, speed on the surface, ability to stay down, readiness in action"; going into all the different points. "Now, you will take a plus where I am out and I will take the minus; and where you are out I will take the plus and you take the minus, and if at the end you have more plusses than I, then your idea is a good one." And that is the usual way with so many of them. They come with the one idea, and we have to fit the other nine out of ten to it.

On ship protection we have had at least three thousand. The Army had two hundred centrifugal guns, and, to beat the submarines, I do not know how many. Everybody has a baby submarine, from Mr. Ford down. When you know exactly what a torpedo can do, what its speed is, what its power is, that it is the development of years of study and has the finest mechanism that can possibly be made—nothing finer in workmanship; takes an enormous amount of power to drive it at high speed, you calculate that a baby submarine about forty feet long and four and one-half feet in diameter would take at least a thousand horsepower to drive at the speed he wanted, and if any man thinks that he can get a thousand horsepower in a boat of that size, then he is a better engineer than I am.

Some time ago a friend of mine asked what people could do to help. "Well," I said, "you have your brawn, your brains, and your bonds. We will call them faith, hope, and charity. You have faith in your brawn and hope in your brains, and," I said, "I do not know but the Bible is right: perhaps charity is the best of them all."

The biggest engineering job that the world knows to-day is this war. Going back to our definition of the engineer, the greatest engineer in this world is the President of the United States. Gentlemen, follow him.

THE WAR IN THE AIR*

By G. DOUGLAS WARDROP

EDITOR, "AERIAL AGE WEEKLY," NEW YORK

AERONAUTICAL enthusiasts believe that the air service is going to prove to be the most important single service in either land or naval warfare. In talking only yesterday with the Board of British Officers who have come to this country for the purpose of coöperating with our Army and Navy, they stated that, while they appreciate what America is going to do for the Allies in the way of supplies and in the way of providing human material, they agree that the most important coöperation we are going to extend to the armies in the field is to be the huge air fleet we have already started building in this country. When, two months ago, Secretary of War Baker announced that he had accepted a program calling for the building of 22,000 aeroplanes and thereby committed this country to a huge air program, and subsequently, when he increased those figures by saying that by December, 1918, America would have built and equipped 50,000 aeroplanes, then he accepted a program beyond the happiest expectations of any aeronautical expert or enthusiast in the country. The entire automotive industries—motor boat, automobile, tractor—are doing their best to coöperate with the original aeronautical industry in building the parts for the 50,000 machines we are to deliver to Europe during the next twelve months.

G. DOUGLAS WARDROP

It was interesting to me to read the other day in a German paper that, almost coincident with the first announcement of the Secretary of War, Germany had decided to eliminate for the time being the Zeppelin construction, and to-day every piano factory, every furniture factory—every factory that was concerned with the building of Zeppelins and dirigible types of aircraft is turning its attention to the building of heavier-than-air machines—aeroplanes. The aerial observers of the Allies who have gone sufficiently far behind the German lines have discovered that the Germans, instead of constructing dirigibles, are now building the largest and latest types of bombing machines, and these are being tested in great quantities. In other words, Germany has accepted our challenge, and, while every engineering industry in this country is in some way interested and concerned with our aeronautical program, our engineers must not persuade themselves that we have an easy task in hand.

To-day the war map of Europe demonstrates that Germany has pretty nearly realized what she has set out to accomplish. When the war started, in 1914, the German Empire already had a definite desire to secure a clear open stretch of territory from Berlin to Bagdad, and that to-day is realized. The conditions during the last three years have prevented, fortunately, a realization of many of the Teutonic plans, but the fact remains that their first endeavor has been achieved. We have to recognize that we are not getting into a campaign where we are going on the already-won side, but on the side that is at the moment on the ascendency, and it is up to us to accelerate for that side the ascendency, and especially in the air. Germany, single-handed—for we can almost eliminate Austria—has kept her own in the air war. Step by step, when the Allies for a short period had a better machine, it was only a matter of three or four weeks until a machine came from the other side of the trenches that was equally as good, if not a trifle better.

The ingenuity of the Germans in meeting some of these steps is immensely interesting. About six months ago the fabric market in Germany was peculiarly threatened. For a long time they had been utilizing linen, and to-day we are almost exclusively utilizing it in this country. Germany, running short of linen, began to use cotton. Experts were kept busy, and it was found that the supply could be conserved by using a very thin product, covered with casein, a by-product of buttermilk. That almost muslin-like fabric of cotton has been covered with casein and subsequently treated with varnish, and to-day Germany is making her machines with this type of fabric and saving her cotton supply to the extent of a little over fifty per cent. I have it from fairly reliable authority that only a few weeks ago a machine was brought down on the French lines made of very thin sheet metal, stamped out as in the ordinary metal-stamping process. Those of you present who are engineers will appreciate exactly what that means. If successful, Germany will be able to turn out as many a day as she desires. The stamping process can be accelerated to any degree desirable, and if that form of construction is adopted we will again have another unit to consider in the matter of dominant production for the Allies as against Germany. They have secured thru their territory huge supplies of raw material in northern France and Roumania, and there is no question that Germany has enough raw material to last for almost any kind of enlarged air program for several years to come.

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* Address delivered before the Engineers' Club, December 19, 1917.

I was talking recently with a Swede who had been in Germany only five months ago; he said that much of our feeling that Germany is on her knees, from the standpoint of lack of raw material, is due merely to a lack of knowledge concerning the real situation. Germany, when the war broke out, took the matter scientifically. Its whole system of education and dissemination of knowledge to the people is such that they immediately began to take as a matter of course the stringencies of war and accepted as a desirable thing that their portion should be cut down, that their materials should be limited, and so, as many of you know, the immense stores of material in Germany are being given out by card in every direction with the view that they shall be spread over the necessary period of years during which it is expected by the Germans that they will be successful in achieving their object. So when we as engineers face the situation of giving our Allies supremacy of the air we have not for a moment to make ourselves believe that we have an easy program in hand. We shall have to work seven days a week, twenty-four hours a day, with all our energies toward the end that in July of next year, as our War Department hopefully states it, we shall turn into the field 20,000 aero-

BRITISH ANTI-AIRCRAFT GUN SILHOUETTED AGAINST THE SKY. BRITISH OFFICIAL PHOTO planes. If we do, we shall thereby give very real assistance to the Allies, but not the dominance of the air.

The progress of the war, notwithstanding the fact that it is only three years, has been more phenomenal in the air service than in any other unit of modern warfare. When the war started there were available only a few hundred machines. To-day it is stated on the authority of the military experts that it is reasonable to believe there are in use in the different countries at war somewhere in the neighborhood of 25,000 machines. There has been a wonderful expansion of aeronautical production and in the matter of records of speed and endurance. Only the other day an aviator arrived in England with three stops *en route*—made a successful stop at Constantinople, dropped a quantity of bombs, and returned, covering a distance of nearly two thousand miles. Furthermore, reports came thru only yesterday that a machine remained in the air but a few minutes less than twenty-four hours before making a landing.

When the war broke out a speed of around a hundred miles an hour for an aeroplane was considered excessive. To-day we have official reports from Italy stating that the Pomelio, a very small machine with a wing spread of about eighteen feet, has developed a speed in excess of one hundred and fifty miles an hour, and to-day plans are being laid for another type of plane with an even greater horsepower which, when completed, will develop a speed of somewhere in the neighborhood of one hundred and seventy miles per hour.

Before the war broke out we had it conclusively proved by diagrams and calculus that no machine could successfully traverse the air at a greater speed than one hundred and twenty miles an hour. This looked fine on paper, but practical tests have given the lie to trigonometry in this as in a number of directions in the war.

When the real air battle commences next year we shall have in the air a realization of what we have hitherto accepted as naval strategy. It will be the endeavor of the Allies or the Germans to eliminate from the air the fast-fighting machines of the enemy. When the fast-fighting machines of one side have gone, then will come on the heavier machines, reconnaissance machines. Then will come dreadnoughts of the air with huge carrying capacity. Do you realize that to-day a machine is successfully flown in Italy that takes into the air a load of bombs a little in excess of two and a half tons? We have to-day literally reached the aeronautical dreadnought stage, and when these dreadnoughts pass over the line, not in tens but hundreds and possibly thousands, then we shall realize the real war in the air.

Can you imagine the havoc that could be wrought with a fleet of one hundred bomb-carrying aeroplanes, each carrying two and a half tons of bombs? Only the other day there was an interesting front page of the *New York Times*. On one column it was shown how the Italians met with success on the frontier. The Italian machines had passed over the trench lines, opposing temporarily the transmission of enemy troops and consequently giving the Italians an opportunity to rush on successfully. The Italians took advantage of this and made a dent in the Austrian line. In the very next column a statement was made concerning the condition on the Western Front, where it was noticed a certain delay had occurred in the affairs of the Germans at certain railroad sidings and railroad junctions. One lesson applied to the other. If the French had had a sufficient number of Italian

ROLL-CALL PREPARATORY TO SETTING-UP EXERCISES AT ONE OF THE U. S. ARMY AVIATION FIELDS

HOISTING A SEAPLANE OF THE ROYAL NAVAL AIR SERVICE ON BOARD A MOTHER-SHIP AFTER A RECONNAISSANCE FLIGHT OVER THE NORTH SEA

types of machines carrying loads of bombs, some weighing upward of one hundred and fifty pounds, and had dropped them on the precise spots where the delay occurred, we can imagine that the delay could have been continued indefinitely. Had it been so continued, then our good friend Byng would have had an excellent opportunity of driving the wedge a little further. That has been the difficulty on the Western Front—a lack of coöperation among the British and the French. While these two countries were facing the same problems, two separate laboratories, one in France and one in Great Britain, were conducting a series of testing concerning the same proposition, but results concerning these tests were not transferred until a few months ago. The scientists who were back of the lines did not think it desirable to compare notes. It has been a very difficult matter to eliminate professional jealousy. Only now are they beginning to eliminate that thru sheer necessity. If you could get the experts of the Allies—French, British, Italian, and American—to sit in council, it would do more than any other getting together possible.

In the human side of the war in the air we have built up in three years the most remarkable body of aviators the world has ever seen. They are mostly young men. The desirable airman is from nineteen to twenty-four years of age. Then he has the courage of youth—the nerve and the spirit of courage which are necessary for an airman. Every airman, when in the air, is face to face with death. When he gets in the air against an opponent, he is face to face with death twice certain. You can stand in the trenches without seeing anybody on the other side. You know during the day you can throw over hand grenades and fire your rifle. When in the air you see your opponent and know that the best man is going to make his landing on his home hangar. The other—no one knows where. That spirit of gallantry brought forth a spirit of human sympathy, and at precisely the same time next day an aviator would fly over that side, fly low and drop down a wreath of flowers with a message and the little personal belongings of the aviator. It does not mean much to have a cigarette case or photograph or souvenir that may have been of a very personal nature, but away from the lines where the sweetheart is waiting it means a great deal to have that little souvenir of her boy who fought and fell; and that spirit was demonstrated on many occasions, when such souvenirs as these were sent back to the home.

A REMARKABLE PHOTOGRAPH OF A GERMAN MACHINE WITH THE OBSERVER INDICATING CLEARLY BY RAISING HIS HANDS ABOVE HIS HEAD THAT HE HAS HAD ENOUGH

On the other hand, there were humorous incidents. A French aviator was sent over the lines with a new type of machine; it was the first time it had been tested, and the mechanic did not pay as close attention to the machine as he should and suddenly the pilot discovered that he had run short of gasoline, with the result that he had to land on the German lines. The Germans wondered how they could succeed in getting a test made. It was at once realized that if he made the test he would doubtless make a get-away. It was decided that two German officers should get into the machine, each with a revolver at his ear. It may not have occurred to them that had they shot him it would have brought them down quite as surely as him, but they got into the machine and the French aviator went up and up until he got somewhere around the 10,000-foot mark, when the Germans began to get just a trifle nervous and they suggested that it would be a good idea to take them down again. It so happened that this Frenchman was one of the best exhibition flyers and stuntsters that was known before the war, so he stated he would be glad to bring them down. He nosed down the machine and made a perfect loop. The Germans went down!

Almost simultaneously with the receipt of that description a report came thru from the Russian front where a young Austrian officer who was making his last flight had to come down and rush in line. When the Austrian officers went to capture his machine they found him crying bitterly—something remarkable for an airman to do. They discovered that on the day afterward he was to be at the altar by the side of his bride to be married. The Austrian officer, notwithstanding it was in the fall when few flowers were available, succeeded in scraping enough leaves and flowers to make a bouquet, to which was attached a message from the officer somewhat along the lines that they were tremendously sorry that the fates of war had transferred the young officer to their keeping for the time being, but they wanted to assure the young lady who was waiting that when the war was over her man would be delivered safely to her, and the interruption of festivities was a subject of great regret to the Austrian officer. So it went for the first two years of the war. To-day air warfare has assumed too grim proportions for such festivities or courtesies, when you realize that machines are not going over the lines in ones or twos, but flying just the same as men go toward the trenches with their rifles and bayonets, in tens and twenties, each in their allotted space. The time has passed when the wreaths of flowers are eliminated; but it was a happy stage of the war in the air and it represented in that war in the air a phase of development. There was a time when the gallant soldiers of yore went out with armor plate, but that time has passed. So has the air courtesy gone. Next year the grim tussle will come when there will be in the air at one time probably several thousand machines. It is difficult to imagine the picturesque sight of such a fleet, and it is necessary to see a number of machines in the air before we can begin to appreciate that side of the subject.

STANDARDIZING METHODS OF A MODERN UTILITY*

By WM. F. JOHNSON

IN the conduct of modern business the application of efficient methods is essential. The development of large industrial corporations is justified on the basis that centralized effort makes for efficiency. To the modern business concern of recognized standing, efficiency means not alone maximum output, but the application of the doctrine of satisfaction.

There is evidence on every hand of the effort on the part of manufacturers to render service; to improve the quality of their products. These are possible only when the fundamental determination of values, applied in the several stages of manufacture or output, are made with all reasonable precision.

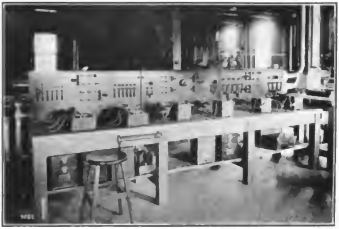
The application of electricity to practically every industry has been incident to a development in the electrical world itself thru which electrical appliances for use in the allied sciences and industries were possible. Some one has said that there is perhaps less excuse for not being successful when using electticity than when using any other agent. Perhaps our contemporary scientists are justified in such an attitude.

Recent developments in the engineering world have made possible a marked improvement in the efficiency of operation not alone in engineering concerns, but in all industries. The application of the results of the most recent investigations along the lines of scientific research have brought within the reach of the practical operator, supervisor, administrator, and engineer, ready devices by means of which the efficiency of operation can be determined with precision.

The modern electric utility must include in its equipment standards for reference having a degree of precision, dependent upon the character and magnitude of its efforts. Owing to the education of the public, and the consequent establishment of Public Service Commissions, Statutes, and Ordinances, it is made obligatory upon the utility to have available certain reference standards, or to make provision for having working standards checked at some recognized laboratory; but the truly efficient utility, the magnitude and scope of whose work is sufficient to warrant it, has been maintaining a standardizing laboratory during a period considerably in advance of the application of modern statutes or regulations, and in many instances is more exacting in its requirements than the most critical commission.

The following figures are taken from the N. E. L. A. Report of 1911, showing the result of improvement in equipment, and the evident intent of operating companies to render accurate, dependable service.

A certain representative company improved its facilities during a period of eight years to the extent that made possible the checking of 50 per cent. more of its meters in service, with a consequent improvement in accuracy of registration of approximately 10 per cent.



THE PHILADELPHIA ELECTRIC CO. LABORATORY. ROTATING STANDARDS TEST BENCH

Another company presents the following record:

1910— 7.4 per cent. of meters tested were more than 4 per cent. fast.
17.4 per cent. of meters tested were more than 4 per cent. slow.
75 per cent. between 4 per cent. fast and 4 per cent. slow.
1914— 2.9 per cent. of meters tested were more than 4 per cent. fast.
8.2 per cent. of meters tested were more than 4 per cent. slow.
88.9 per cent. between 4 per cent. fast and 4 per cent. slow.

During recent years, the facilities for testing in every utility have been increased, and the types of meters improved, so that it is not unreasonable to say that the average accuracy of the meters of any modern utility is within 2 per cent. of being O. K.

There are at the present time, 31 states which have Public Service Commissions.

The requirements of the Commissions in the different states vary to some extent, but they all serve the useful purpose of standardizing methods, and by defining legal standards for service, facilitate the work of the dependable utility which has always maintained the highest possible standards.

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* Delivered before the Philadelphia Section of the American Institute of Electrical Engineers at the Engineers' Club, November 12, 1917.

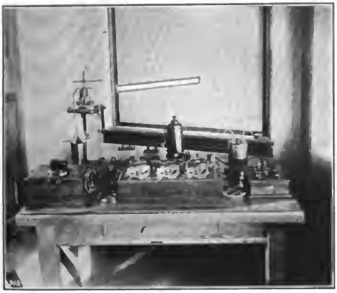
The Philadelphia Electric Company has maintained a Standardizing Laboratory during more than 15 years, and since 1902, when the equipment included a Morris E. Leeds dial type Potentiometer with the accessories, including early type of Weston Standard and Normal Cells, M. E. Leeds Resisters, etc., the equipment has been added to from time to time. This old potentiometer, while still in operative condition, is used for exhibition purposes only and serves as an interesting example of one step in the development of precision apparatus.

The standardizing equipment at present includes the following:

6-Weston Standard Cells.
13-Standard Resisters (0.0001 ohm to 1000 ohms).
Precision Potentiometer and Volt Box.
Precision Kelvin Double Bridge.
Precision Wheatstone Bridge.

Oscillograph, standard condensers, galvanometers, resistance boxes, precision current and potential transformers, etc. Secondary standards, such as indicating voltmeters, ammeters and wattmeters, are used for directly checking the portable working standards.

The primary and secondary standards are the best obtainable, being of the most recent design, the same as those in use in the U. S. Bureau of Standards and other recognized testing laboratories.



PHILADELPHIA ELECTRIC CO. LABORATORY
PRECISION POTENTIOMETER EQUIPMENT

The standards are divided into two groups, one of which is used solely for reference in checking the other. The six Weston Standard Cells are intercompared every two weeks, two of them being reserved for use as primary standards, and these two cells are checked every six months at either Washington or New York. All secondary standard resisters, bridges, volt boxes, and transformers are checked in our laboratory against the primary standards every six months, and at one of the outside laboratories at least once every two years.

The acceptance test of every new piece of standard apparatus includes a check by either the Bureau of Standards or the Electrical Testing Laboratories, and all primary standards are checked regularly by one of these two laboratories, the policy of the company being to alternate between the two.

This policy of having a check made by a responsible, disinterested party precludes the possibility of fundamental errors being made, and also adds an element of stability and security to a system which embraces those features which are necessary in the conduct of a modern utility.

The secondary standards are checked against the primary standards twice every month. During a period of 15 months, since the check of the Public Service Commission, these secondary standards have not varied to an extent which would show need of adjustment.

These instruments are kept in a fixed position and used only by a limited number of testers, and while there is no reason for expecting an appreciable error, the periodic check is made to include at least two readings on every range of shunt or multiplier.

PORTABLE INSTRUMENTS

All portable instruments available for use thruout the company are called in for check every two weeks and adjustments are made to bring their accuracy within 0.3 per cent., at the points used. In some few cases it is necessary to issue error cards, owing to scale errors, or when a particular instrument is to be used in work of an unusually precise nature.

All meters and instruments used in any part of meter testing and all primary and secondary laboratory standards have been checked and approved by the Public Service Commission of Pennsylvania.

D. C. METERS

Except in the case of station types, all D. C. meters for use on circuits of more than 300 ampères are equipped with external shunts and in some cases shunts for 200 ampères are used.

The Precision Type of Thomson Double Bridge is particularly useful in the accurate determination of the resistance of meters, shunts or samples submitted for conductivity tests.

The meter is connected by means of low-resistance leads to the shunt and is constructed as a rule for a maximum current of ten ampères. It is the policy of manufacturers to standardize their products and in the case of meter shunts the nominal drop across them is 80 millivolts, regardless of their capacity.

The modern utility cannot afford to accept nominal values for any part of its system, and so the meter and shunts with leads must be accurately measured before the meter is tested and installed. Take for instance a shunt whose rating is given as 80 millivolts at 1000 ampères; this would mean an ohmic resistance of 0.00008 (eight hundred-thousandths) of an ohm, 1 per cent. of which would be but 0.0000008 (eight ten-millionths) of an ohm, which would not be an unreasonable error in the process of manufacture of shunts for commercial work generally. However, if this 1 per cent. error were allowed to exist in the fundamental stages of meter tests, it would at least tend to restrict the limits of error as defined and maintained by the company officials, and would encourage a disregard for the refinements that are expected of testers in every department of the company. Therefore, the modern utility cannot accept nominal values for anything appertaining to its equipment.

It is seldom that the tests of a new shunt show an error of more than 1 or 2 per cent., but it is the duty of the standardizing division to determine exact values in so far as is possible, and with the modern equipment of precision bridges, resisters, etc., it is not unreasonable to expect an accuracy of the order of 0.05 per cent. in fundamental determination generally. Every shunt type meter with its leads and shunts is accurately measured by means of the Thomson Double Bridge before being tested. The meter with its leads attached is set up and the normal current (usually 10 ampères) is passed thru the leads and meter coils, and the actual ohmic resistances of the system and of the meter coils separately are determined by reference to a standard resister of the same order. The shunt or shunts are then measured while carrying their rated current, and the percentage accuracy of the system (meter coil and leads to shunt) is determined. If this is not more than 3 per cent. in error, the meter is so adjusted as to compensate for this difference, otherwise new leads are provided. The meter is then checked in the laboratory, and adjusted to the greatest accuracy attainable in a system involving precise wattmeters, accurate stop watches and expert testers. (This accuracy is within 0.2 per cent.)

The meters are then installed on the consumers' premises and rechecked against portable standards.

Periodic checks of these meters are made and the shunts are rechecked according to schedule, as well as when at any time there is a suggestion of mechanical damage.

A. C. METERS

Meters for use on alternating-current circuits are checked and adjusted in the laboratory prior to installation and are rechecked in place on consumers' premises.

A regular schedule for periodic checking of all meters is maintained, the frequency of such checks being dependent upon the size of the meter, the nature of the load, and operating conditions generally.

Every potential transformer to be used with a meter is tested for ratio, and every current transformers for ratio and phase angle before installation.

The meter is adjusted to register 100 per cent. by compensating for the errors in transformation.

ROTATING STANDARDS

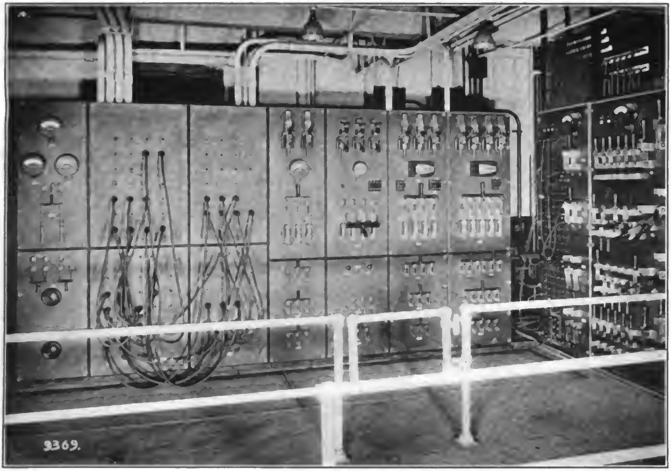
For tests on consumers' premises, the Philadelphia Electric Company method is employed. This method is what is known as a one-man method, since it requires but one tester with a rotating standard equipped with a head phone attachment. This attachment causes a click in the head phone at every revolution of the standard and the tester determines the speed of rotation of the meter under test, makes note of the accuracy as found, and if this is in error more than 0.6 per cent. the meter is adjusted.

PHILADELPHIA ELECTRIC CO. LABORATORY PRIMARY AND SECONDARY STANDARDS

In accordance with the policy of the Philadelphia Electric Company during more than five years prior to the establishment of the Public Service Commission in this state, and in accord with the continuance of this policy which conforms to the requirements of the Commission's rulings, rotating standards are checked at least once every two weeks when in service. These standards are called in for check, examined, cleaned, tested and adjusted by men whose time is devoted to this work entirely. Wattmeters reserved for this testing are checked every week against the Laboratory Secondary Standards. A complete "as found" and "as left" record of every test is kept and these records remain on file for a period of at least four or five years.

To the modern utility, dependability (the policy of rendering service, of satisfying, and of being satisfied) does not end with the acceptance and adoption of apparatus and methods already countenanced or approved by the engineering profession, but includes the maintenance of facilities for the development of additional methods, the improvement of existing processes.

Such developments as the Philadelphia Electric Company method of meter testing, by means of which one man can test accurately a meter on the consumers' premises—the Boston Edison Company method of checking rotating standards—by which the test is conducted with a minimum amount of manual effort, the New York Edison Company method of testing large capacity D. C. meters with the aid of Edison Portable Storage Battery—the maintenance by Electric Utilities generally of laboratory equipment, by means of which precise fundamental values can be transferred to practical working standards, are but an earnest of the intent on the part of the modern utility to discharge its obligations to the profession and to the public by the acceptance of those principles which make for efficiency, service, and satisfaction.



MAIN CONTROL AND DISTRIBUTING PANELS FOR LABORATORY TESTS. 110-220 VOLTS D. C., 25 AND 60 CYCLE A. C., 4 TO 600 VOLTS CURRENT AND POTENTIAL BATTERIES

INDUSTRIAL HOUSING*

BY H. W. FORSTER

PRESENT SHORTAGE IN HOUSING

THERE exists a nation-wide shortage of housing in our industrial centers. The situation is critical. Many of our communities are already suffering seriously from lack of adequate housing for their workmen. The situation is growing worse; houses cannot be conjured out of the earth, but require considerable time to build in large numbers. Vigorous attack upon this problem has been made in many cities and must be made generally thruout the country.

The reasons for the present shortage are primarily:

(*a*) Under ordinary business conditions there is no appreciable excess of adequate housing in our large cities.

(*b*) Normal building activities, during the past two years in particular, have been materially retarded because of the high cost of material and labor.

(*c*) The great rush of workmen to our industrial centers has seriously accentuated what would under ordinary conditions already be an acute situation.

Employers, individually or collectively, are behind a considerable number of housing projects now under way, and the investigation of the United States Government into the situation, with particular regard to the prompt delivery of large munition orders, has indicated the necessity of remedying the conditions in a number of districts if production under government contracts is not seriously to suffer.

It is interesting to note that the concentration of Great Britain upon war operations has caused so serious a shortage in industrial housing that it has been recommended that $5,000,000,000 be appropriated by the Government for the purpose of building one million homes after the close of the war, partly to make up this housing shortage and partly to furnish employment for a considerable proportion of the soldiers who will return from the front.

WHY ADEQUATE HOUSING IS ESSENTIAL

Gradually it has been borne in upon us that, as it is impossible to get pure water from an impure source or good fruit from poor seeds, so it is impossible to get stable, efficient and satisfied labor from congested and unsanitary homes.

Most progressive employers have realized this for a considerable length of time, but it has never been brought home so forcibly as under present conditions, when they are trying to bring to their plants the best types of men. Bad news spreads rapidly, and American labor, including our foreigners, is well advised as to general housing inadequacy of our industrial centers. Many good men refuse to go to such points to apply for work, and those that come are very likely to find conditions unsatisfactory, to stay but a short time, and to move on.

The most obvious objection to crowded housing is the undermining effect upon health. The records are clear upon this point. The greater the crowding the greater the tuberculosis percentage.

Good morals among the people are a national, city, and an industrial asset. Morals are seriously affected by crowding of individual families, more seriously by crowding together of several families, and most seriously by the addition of boarders under congested conditions.

The general experience has been that unhealthy living and a lower standard of morals, coupled with uncomfortable, inconvenient, and unæsthetic living conditions, have a very decided effect upon the efficiency of the worker.

In order to get efficiency out of the workmen that we now have, and to take care of additional ones, we must have adequate industrial housing.

TYPE OF HOUSING THAT IS NEEDED

In practically every community we are confronted by the need of housing, both for American and for foreign workmen. It is difficult to ascertain the total housing need for a community, and even more difficult to determine what proportion of the total need is for Americans and for foreigners. Generally speaking, most recent industrial housing developments have been designed primarily to take care of Americans of the higher type, probably on the assumption that, as these families vacated houses they now occupied, the less desirable quarters would automatically become available to those farther down in the social or financial scale.

It is, however, believed very desirable to provide new houses of adequate types for foreign workmen in those communities where many are found, and that means practically every community from the central portions of the country to the Atlantic seaboard.

It is obvious that it is necessary to provide housing to take care of the following situation:

(*a*) Families living by themselves.
(*b*) Families who take boarders.
(*c*) Boarding-houses.

Size of Houses:

A recent compilation of data covering some 200 industrial housing projects, made by the United State Government, developed the following information on the size of houses:

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* Address delivered before the Philadelphia Safety Council at the Engineers' Club, November 30, 1917.

(*a*) Data secured on 17,643 houses.
(*b*) One-third of these were four-room size.
(*c*) One-sixth of these were five-room size.
(*d*) One-sixth of these were six-room size.

The average family generally consists of father, mother, and three children, and properly to house such a family there should be available the following rooms:

(*a*) Three bedrooms—one for the parents, one for the male children, and one for the female children.

(*b*) A combined kitchen, dining-room, and living-room, or two rooms—one for kitchen and dining-room purposes and the other for living purposes.

In other words, four- and five-room houses are theoretically correct, especially for foreign families, and experience will bear out that these are the most popular sizes.

For larger families, and particularly for those who desire to keep a few boarders, the six-room houses have proved popular among foreigners.

The average American family unquestionably prefers about a six-room house if it can afford it.

Design:

The United States Government report, referred to above, and which was presented by Mr. Magnussen at the National Housing Association Conference in Chicago, October, 1917, stated that the information regarding 53,176 houses indicated the following arrangement:

(*a*) 48 per cent. single houses.
(*b*) 35 per cent. double houses.
(*c*) 11 per cent. row houses.
(*d*) 6 per cent. no information.

There is little doubt that the single house is the ideal house, and that this is the best house to build where it is expected to sell.

It is not difficult to sell half houses where they are built in pairs, but it is difficult, except in one or two of our American cities, to sell row houses individually.

Experience seems to indicate that row houses should be intended for renting purposes, as they do not readily sell, and they lower building costs, and less real estate occupied makes lower rents possible.

It is necessary to call attention to the fact that the smaller the house the better should be the design. Where one general room is used for several purposes and bedrooms are small, the importance of anticipating the actual need of the occupants is particularly great. It is pleasing to note that a number of architects have realized this, and have developed very excellent plans for relatively small low-cost houses.

Equipment:

Company after company that has put up housing for its employes has been pained to discover that the cost of this housing was running far higher than anticipated, and because of this fact it would not be possible to earn a satisfactory return upon the money if rents were to be on a scale which their workmen could afford.

Analyzing each situation has generally developed the fact that the employer has tried to give too much to his people. The engineer who built an industrial plant 50 per cent. larger than necessary and who added a considerable number of frills which were not essential would be no more at fault than the man who built unnecessarily large and elaborately appointed houses for working people. To be successful, industrial housing must be upon the same economic basis as any other form of industrial operation.

Looking after this question a little more closely, we find, for example, such instances as the following:

(*a*) Building generally six-room houses where four- and five-room houses would answer very well.

(*b*) Putting a large amount of money into excellent roads and cement sidewalks, when it would be entirely feasible to keep such improvements for some time in the future. A very large percentage of our Americans of the better class are to-day living on unpaved streets, and are making use of cinder or plank walks.

(*c*) Furnace or other central heat is particularly expensive under present conditions, and in many houses superfluous. Most families who come from less pretentious homes own a supply of stoves, are used to using them, and, in fact, most of the smaller homes rely upon the kitchen stove to heat the combined kitchen, dining, and living room, and to provide a little heat for the balance of the house.

(*d*) Running water is absolutely essential, because of its great convenience and because of the menace which always exists with wells. A sewer system, on the other hand, is not nearly so important, and the cost of many industrial housing projects has run up materially by the necessity of installing a very elaborate sewer system in order to provide for the most modern plumbing.

Where developments are in outlying sections, it is entirely feasible to delay the installation of sewers for some future time. With running water, a privy does not constitute as much of a menace as where wells are used. More pretentious houses or groups of houses can be provided with cesspools.

(*e*) It is a hopeful sign that certain types of foreigners demand a bathroom in any house which they purchase or rent, but a great number of foreigners do not object if bathroom equipment is not provided. In workmen's houses bathrooms are occasionally afterward added and are placed in basements where there is sufficient room, and it is, of course, feasible to design a house in which it will later on be possible to place a bathtub without material change or expense.

(*f*) Electric light in most communities is considered almost a necessity, and forms a convenient, low-priced, and relatively safe form of lighting. The need of extending gas to houses for workmen, the women in which generally are used to cooking on a coal stove, is not nearly so important as a rule.

Materials of Construction:

Industrial housing is now being put up of all types of construction, including frame, stucco on wood, brick veneer, brick, tile, and reinforced concrete. The best material to select will, of course, vary with locality and will depend primarily upon cost, quick availability, speed of construction, and, what is very important and frequently overlooked, the effect upon depreciation and upkeep on a concrete house which is rented will probably be in the vicinity of 2½ per cent. per year, and it may be double this in a frame house.

COST OF INDUSTRIAL HOUSING

Rent That the Workmen Can Pay:

The fundamental question, if industrial housing is to be upon a sane, businesslike basis, is how much rent workmen can afford to pay for their homes.

There has been a tendency to make use of the general rule that 20 per cent. of wages could be paid for rent, and 25 per cent. where payments were on the home-buying basis.

While the 20 per cent. figure works out quite closely in many average cases, the problem is how much the man has left for his rent and other expenses after he has paid for the necessary food. Food comes first in the scale of essential human needs. Unfortunately, the man with many mouths to feed and the heavy food bills has more need of a larger and more costly house and less money to spare for the purpose.

Recent careful investigations and calculations of the minimum cost of food necessary properly to feed an average family is as follows:

(*a*) Father—150-pound laborer	3000 calories
(*b*) Mother—150-pound woman, working hard	3000 calories
(*c*) 12- to 15-year-old-boy	4500 calories
(*d*) Child of about 3	1300 calories
(*e*) Child of about 6 to 8	2500 calories
Total	14,300 calories

These figures are generous for growing children, but only moderately so for the parents.

Assuming intelligent purchasing of food necessary to have the above total number of calories properly proportioned to take care of the needs of the body, the minimum cost of 1000 calories to-day will be about 11 cents, or about $1.57 per day, or something like $47 per month.

It is true that many families are undernourished by virtue of their buying insufficient food, but it is also true that the average housewife does not buy with scientific intelligence, and consequently what is saved by undernourishment probably is spent thru unwise purchasing.

The problem, then, is to subtract from the man's income the necessary food expenditures, and then take a percentage of the balance as being available for rent. This percentage has been placed at a maximum of 40, especially with low-wage workers. The man earning $90 per month, spending $47 for food, has $43 left for all other expenses. If he pays 40 per cent. of this for rent, he has approximately $17 as a maximum rent item. Many workmen, particularly skilled Americans, can and do pay considerably higher rents, but there are very large numbers whose rent-paying capacity ranges from $10 to $15 per month.

Referring again to Mr. Magnussen's figures, we find that out of 17,643 houses, 69 per cent. of the four-, five-, and six-room size rented for not over $8 per month. Such a rental is not economically possible in our cities, where land and houses now cost so much, nor is it necessary with the relatively high wages which are now paid. It must not be forgotten that these figures apply to a large extent to cotton mills and mining towns, where houses often are small, poorly built, poorly maintained, and where low house rent, unfortunately, is a factor in establishing wage scales.

It is interesting to observe from Mr. Magnussen's address that 57 companies, having invested about $15,000,000 in houses, earned a gross of 8.3 per cent. average over a five-year period, that eight coal companies with $2,800,000 invested earned 11 per cent. average over a five-year period, and that one company's annual return was as high as 20 per cent. of its investment.

What Housing To-day May Cost:

If houses are to be rented upon a 10 per cent. gross return basis, which is an average figure, the total cost of the house to the man who can pay $17 per month rent should not exceed $2000, and to the man whose rent is to be $10 per month not more than $1200.

Where houses are built of reinforced concrete, it probably is good business to rent them for 9 per cent., or even 8 per cent. of their value, because of relatively low depreciation and upkeep. With frame houses, 10 per cent. is the absolute minimum that is advisable, made up as follows:

(*a*) Return on investment—5 per cent.
(*b*) Taxes—1 per cent.
(*c*) Depreciation (sinking fund)—2 per cent.
(*d*) Upkeep—2 per cent.

These figures for depreciation and upkeep are probably liberal, but form a margin of safety, partly to take care of vacancies.

What Houses Actually Cost To-day:

The range in house-building costs is exceedingly great. In the South, where frame construction is common and no elaborate heating system is necessary, attractive cottages are being built for figures as low as $700 to $800.

Four-room, well-appointed houses for rental purposes can be built in the residence section of most cities for figures not to exceed $2000.

Splendidly designed six-room houses of attractive appearance, with all modern improvements, in large developments have been put up at costs of from $3000 to $4000.

Charity to be Avoided:

The consensus of opinion of those who have studied the industrial housing problem is very decidedly against anything savoring of charity or paternalism. The essential arguments are:

(*a*) Workmen resent anything of this type, being possessed of quite as much self-respect as the average citizen of somewhat higher social standing. Workmen feel that they should pay their way and that they should receive adequate wages to enable them to do this.

(*b*) Any business activity which is not a money-making one is bound to prove unpopular in the long run, and industrial housing that is netting 2 per cent. or some such figure is bound not to be kept up in a manner which experience has shown to be absolutely essential to get the best results.

(*c*) If an employer has not sufficient houses to take care of all of his people, there is bound to be discrimination.

(*d*) The building in a large community of some houses which are not rented on a businesslike business is bound to upset real estate values generally.

Housing projects where houses are rented or sold should be upon a basis to return at least 5 per cent. and preferably 6 per cent. The advantages of better labor conditions will generally make the housing investment an attractive one.

SELLING AND RENT

It is generally believed that houses should be sold in so far as it is practical to do so. A man who buys a house is a better citizen, is less likely to take part in labor disturbances, and is almost bound not to leave the community.

The monthly-payment method of selling houses to both American and foreign workmen is practically standard. Initial payment, preferably 10 per cent., closes the deal, and monthly payments upon a slightly higher basis than the rent take care of the principal and interest in a period of ten to twelve years.

It is necessary, however, in every industrial community to have a considerable percentage of houses for rent purposes, as many employes cannot and will not buy, and these must be taken care of. On the other hand, if a large proportion of new housing is sold, those who purchase homes will leave other quarters to those who want to rent.

It is particularly important to note that foreigners, on the whole, have stronger home-buying desires than Americans, and that those people who deal with them find them prompt in meeting their obligations and appreciative of business contracts.

AGENCIES FOR SECURING ADDITIONAL HOUSING

Experience during the last two years has made clear the fact that employers cannot look to individuals or real estate operators to provide the necessary housing for their employes. The ordinary workman generally does not build his own house. He is more interested in buying than in building. He is not certain of the permanence of his job and of his desire to settle in the place where he is now working.

The real estate operators are uncertain as to how long rush business will continue, have no enthusiasm for putting their money into industrial housing, nor the necessary funds to handle big projects. This, then, has made it necessary for employers, either individually or collectively, to provide at least a portion of the housing of which their communities are in need. A considerable number of such projects are now actively under way and, on the whole, have been inaugurated along well-conceived lines.

The United States Government is considering putting a very considerable sum of money, $100,000,000 having been mentioned, into industrial housing, either by providing housing directly or by loaning money at low rates of interest to employers who will build the houses.

HOW EMPLOYERS HANDLE HOUSING

A well-established scheme of procedure for action by individual employers or by groups of employers has now been established along the following lines:

(*a*) A separate company formed and a competent management put in charge of its operation. This tends to separate, in the minds of employes at least, the employer from the housing operation, and it relieves the manufacturing men from the responsibility of handling housing as a side line.

(*b*) Careful analysis of conditions is made and the probable needs of the community for a period of years ascertained.

(*c*) A careful plan is developed with an estimate of the amount of money needed for the initial development.

(*d*) Financing by banks for first mortgage on real estate and houses is, of course, easy to secure. At least 50 per cent. can be carried in this way.

(*e*) The housing company has to provide the additional capital, and, where property is sold, carry the second mortgage.

(*f*) Construction is put thru in a systematic, well-thought-out manner, and on a large enough scale to take advantage of wholesale operation methods, and particularly on a long-time basis, so that work forces become highly efficient.

CONCLUSION

The essential facts regarding the industrial housing situation in this country may be stated as follows:

(*a*) There is unquestioned need of additional housing in practically all our industrial centers.

(*b*) Relief can be looked for only from the employers and, in some cases, in part, from the Government.

(*c*) There is no fundamental reason why an employer should hesitate to build houses for his workmen any more than to provide buildings for his machinery and goods.

(*d*) Good houses will rent and sell even in times of business depression, because they will be superior to the average house in the community.

(*e*) The money return on such an investment can be equal to that secured from the first mortgage bond of a subsidiary.

(*f*) Money can gradually be withdrawn from the project.

(*g*) Adequate housing will have a definite effect upon securing labor, reducing labor turnover, bringing up the efficiency of labor, and putting forward the good of the community as a whole.

AN OPTIMISTIC VIEW OF THE FUTURE SUPPLY OF OIL*

BY I. N. KNAPP, M.E.

INTRODUCTORY

PETROLEUM, commonly called oil, is a mixture of hydrocarbons found in Nature in liquid form, and cannot well be discussed without incidental reference to allied bitumens such as asphaltum, maltha, natural gas, and the like. Shale oil is a mixture of hydrocarbons produced by the dry distillation of shale containing kerogen or hydrocarbons in solid form. Tar is the general name of a mixture of liquid hydrocarbons produced by the dry distillation of coal, lignite, and peat from which, by refining, products can be obtained which in many cases can be substituted for those from petroleum and shale oil.

HISTORICAL

History fails to record when the first discoveries of petroleum were made by the human race, but reference is made to it and allied substances in literature of great antiquity. In the ancient cities of Nineveh and Babylon bitumen was used to cement brick, slabs of alabaster, and mosaic pavement, in the construction of temples and palaces. The Egyptians used asphalt for embalming the dead.

Once oil and gas were considered as among the most wonderful things in the world and regarded as manifestations of Deity itself, and so worthy of religious worship. We have accounts of some of the Indian tribes in our own country performing religious ceremonies accompanied by the burning of oil and gas. The medicinal properties of petroleum had been recognized by them before white men set foot in America.

About ten miles northeast of Baku, Russia, there is a fire-worshipers' temple on a site visited by the Parsees for no less than 2500 years. Formerly pilgrims flocked there yearly in great numbers from all parts of India to worship, according to their belief, the holy eternal fires, made by igniting the natural gas escapements found here. About 1880 the Russian Government forbade this.

Now, every five years, a company of fire-worshiping priests from India are allowed to hold a meeting in one of the larger rooms. Their costumes, vessels, etc., are walled up between two of the rooms after each meeting to preserve them for future use.

Pliny, the Roman historian, recorded that "Sicilian oil" was burned in the lamps of the Temple of Jupiter. This was during the first century of the Christian era, and is the earliest mention of petroleum being used for illuminating purposes. In the state of civilization then existing there was but little call for illumination other than that obtained from what we now call fires, and still less in the dark ages that followed.

After a lapse of many centuries, learning and civilization gradually began to assert themselves, and this in turn made a growing demand for artificial lighting that was supplied by lamps which burned whale oil or candles, and tapers which burned solid animal fats or the wax of insects and vegetation.

In the early part of the last century chemical research established the fact that burning fluids could be extracted from the resin of wood, from coal, from shale, and from lignite and peat.

About 1815 the first coal-gas works was established to manufacture and distribute gas from central stations for city lighting. In this way, accidentally, but unavoidably, quantities of coal-tar were produced. For many years this tar was regarded as a refuse product without value and caused considerable expense to get rid of. Later chemical research disclosed its commercial properties, and it is now the source of many valuable hydrocarbon products.

The ever-increasing demand for more and more artificial lighting made the old sources of supply for lamp oil and candles inadequate entirely to meet the many demands for isolated lighting, and this was an important factor in starting the coal and shale oil industry in Scotland about 1850 and its following development on a commercial scale.

Shortly after the success of the Scotch process for distilling oil and paraffin from shale for lamps and candles, a number of "coal oil" refineries were erected in the United States.

By 1860 there were 53 coal oil companies in this country and six refinery plants in the vicinity of Pittsburgh. The plants on the Atlantic seaboard imported "boghead" coal from Scotland and "Albertite" from New Brunswick, and those around Pittsburgh used cannel coal and shale.

The experience gained in producing and refining oil from these sources paved the way for the advent of petroleum.

The first serious public attention was directed to petroleum as a remunerative enterprise when Colonel Drake drilled the first well especially for petroleum in 1859, which led to the development of the great Appalachian oil fields which have since yielded such an immense volume of the finest crude oil in the world.

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* Presented December 4, 1917, before the Mining Engineers, at Engineers' Club.

This great source of cheap oil enabled America quickly and fully to meet the demand for lamp oil, and with further development to supply the people in remote corners of the world with oil for their lamps to mitigate the darkness of night.

Many other uses for the products of the crude hydrocarbon oils besides that of lighting have arisen. One of vast importance to the people of the earth is its use in the internal-combustion engine, a use developed by leaps and bounds in the past ten years and which bids fair to outstrip all other uses. Every demand for more oil may be met by properly utilizing all the sources of hydrocarbons now existing in the crust of the earth.

ORIGIN OF HYDROCARBONS

Many theories have been put forward to account for the origin of petroleum and allied substances. There are two main groups of these hypotheses, one ascribing an inorganic and the other an organic origin.

The celebrated chemists, Bertholet and Mendeljiff, pointed out (in 1869 and 1877) possible chemical reactions by which hydrocarbon compounds could be generated in the earth's interior. Some advocate a volcanic origin of petroleum, and give examples of hydrocarbons in ancient plutonic rocks as well as in present volcanoes. The organic hypotheses can be backed by more familiar facts than those just outilned.

Coal, petroleum, kerogen of the oil shales, and other hydrocarbons are combustible substances, and every other combustible that we know of in Nature is organic in origin. These may be regarded as residues left by the disintegration of living organic substances, which have not met with the quantity of oxygen required for their complete decomposition by decay.

Chemists have produced unmistakable members of the petroleum series, including illuminating oil, lubricating oil, benzine, and paraffin, from the distillation of fish oil.

By observation we know that marsh gas, the chief constituent of natural gas, is a product of slow primary decomposition at low temperature of organic matter contained in sediments, and therefore it is from an organic source. These decompositions are extremely slow. The present pools of oil and gas with the deposits of oil-bearing shale and of coal are the accumulations of enormously long periods of time. It is safe to say, from our present knowledge, that some hydrocarbons may have come from an organic source, but by far the greater amount come from terrestrial and marine vegetation and organisms.

We might well adopt for our conclusions the translation of an inscription placed over a meteorite that fell centuries ago in Europe: "Many men say many things; every one says something; nobody gives a satisfactory account."

GEOLOGY OF PETROLEUM

The geologists tell us that petroleum, with its allied forms, is among the most widely distributed of substances. Its geological limits of profitable production include the whole range of unaltered strata, from the Cambrian rocks to the most recent series of the Quarternary system.

Geology is admittedly more of a historic than exact science, with but few demonstrations of the sort that carry mathematical certainty. The principles of geology are not visionary; they are supported by a great multitude of harmonized facts. But the geologist does not know whether a petroleum-bearing "sand" exists at a given spot beneath the surface, nor whether, if there be a sand, it holds oil or not, nor whether, if the oil be there, it will flow toward a drill hole. But this ignorance of facts, all of them out of sight and out of reach before experiment, he shares with everybody else. No one, absolutely no one, can know such facts before a well is bored.

Petroleum is produced from sedimentary rocks only. Shale and coal are also associated with the same class of rocks. Such rocks are composed of the detritus of older rocks and carried by water, air, and ice in motion into lakes and seas, forming gravels, sands, and clays which may be later consolidated into conglomerates, sandstones, and shales.

In smaller portion the materials are also carried in solution, and the deposits are then called organic, if formed with the aid of life, and chemical without the aid of life. Organic and chemical rocks are limestones, cherts, gypsums, peat, lignite, and coal.

Sedimentary rocks are mostly deposited in layers or beds originally in a horizontal position, or nearly so.

Most of such rocks grew up in the sea, some cover thousands of square miles, and for the accumulation and growth of these enormous deposits vast periods of time were required.

Much terrestrial and marine vegetation with marine, brackish, or fresh-water organisms is thrown down with such deposits, forming in the aggregate a vast amount of carbonaceous and bituminous material sufficient to account for all the hydrocarbons, petroleums, and allied substances found in Nature.

By organic movements the stratified rocks have been arched up, thrown into waves, and crumpled.

The fundamental geologic conditions necessary for a profitable accumulation of oil or gas must be:

First.—A source of supply, probably from carbonaceous material enclosed in sedimentary strata.

Second.—A reservoir rock such as may be found in any porous rock that will allow the passage of fluids between its particles.

Third.—A cover of impervious moisture-holding rocks to seal and hold the oil and gas from loss by dissipation.

In addition to the three fundamental conditions just stated, we should have for the proper theoretical anticlinal conditions:

Fourth.—Water in the porous stratum with the oil and gas.

Fifth.—Geologic structure, or a decided slope of the porous stratum forming anticlines and synclines.

It cannot be doubted that the fifth condition mentioned—geologic structure—does play an important part in the accumulation of oil, and particularly of gas.

To such fields as the anticlinal theory applies it is of economic importance, and the geologist should be consulted to locate favorable points for the accumulations in advance of any drilling. In making such location, the geologist depends on precedent and known facts.

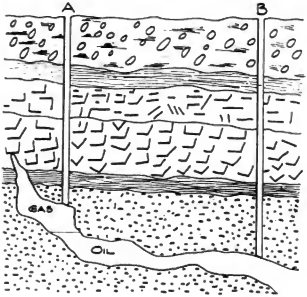
After a productive oil, coal, or shale horizon is once found, geology is of great value in locating other similar areas and is an aid for their proper development.

RESERVOIR ROCKS

All rocks are porous in some degree. Even slate of the closest grain will hold some liquid in its microscopic cavities. Those rocks that are so open-grained or porous that, if a hole be drilled into them, they can be drained of their liquid or gaseous contents are called reservoir rocks.

The fractional part of a rock in which there are open spaces or voids determines its porosity. That is, if a cubic foot of rock will hold, when saturated, one-tenth of a cubic foot of oil or water, such rock is said to have a porosity of ten per cent., for one-tenth of its volume is pore space. If such pore space was filled with gas at 30 atmospheres, then each cubic foot of rock would hold three cubic feet of gas at atmospheric pressure.

During the early years of petroleum development the theory of oil rock crevices obtained great currency, not only among well drillers and well owners, but also among geologists, who examined and reported upon the underground structure of the oil country.



From Henry's Early and Later History of Petroleum Page 212.

FIG. 1

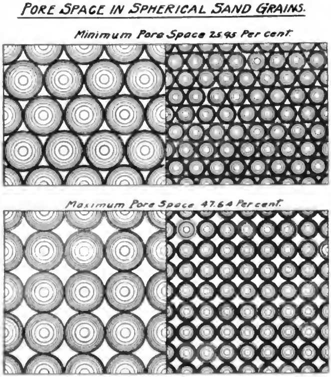
There were others who imagined that the oil lies in a series of lakes or caverns connected by underground streams.

Fig. 1 is from Henry's "Early and Late History of Petroleum," published about 1873 and at that time considered an authority. It has been demonstrated that such cavities do not exist.

OIL SANDS

Any porous or reservoir rock in a horizon where paying pools of oil or gas occur is called by the driller a "sand," whether it be a sand or a limestone rock. When this "sand" is drilled into and oil or gas, or both, are found so that they will flow to the well in paying quantity, it is called a "pay sand," and if not found in paying quantity, the well is said to be a "dry hole" or a "duster," and the sand is said to be "dry," altho it may be heavily charged with salt water.

The drillers' oil and gas sands are rocks that are pierced with millions upon millions of minute connected pores which, when saturated with oil or gas under pressure, form the paying pools of oil and gas.


Pore Space in Spherical Sand Grains.
Minimum Pore Space 25.95 Per cent.
Maximum Pore Space 47.64 Per cent.

From Nineteenth Annual Report U.S. Geol Survey, Part II. Pl. II

FIG. 2

The pore space contained in earth, sand, and rocks has been elaborately investigated. If a theoretical sand is formed of perfect spheres of equal diameter placed a minimum distance apart, the pore space is 25.95 per cent., and at a maximum distance apart, of 47.64 per cent., and this porosity is constant, irrespective of the size of the grain.

Fig. 2 shows this spherical relation.

Fig. 3 shows a table of the constant relation of porosity, irrespective of size.

Fig. 3.

Table to Show Pore Space is Independent of the Diameter of Perfect Spheres Regularly Spaced.

Diameter, sphere inches	Volume, cubic inches	Number in 1 cubic foot	Total volume	Pore space
12	904.78	1	904.7	823.3
6	113.09	8	904.7	823.3
4	33.51	27	904.7	823.3
3	14.137	64	904.7	823.3
2	4.189	216	904.7	823.3
1	.5236	1728	904.7	823.3
½	.06545	13824	904.7	823.3

By experiment it has been found that the porosity of sands occurring in Nature is well within the limits just given.

The porosity of oil and gas sands may be illustrated by a series of microphotographs, all of the same degree of enlargement.

The first (Fig. 4) is that of common sand that will pass a 50-mesh and hold on a 100-mesh screen, in comparison with a Brown & Sharpe scale, having divisions of one one-hundredth of an inch.

Fig. 5 is from a specimen of the Colinga, Calif., oil sand. It is very coarse and is but slightly cemented.

Fig. 6 is from a specimen of Wyoming oil sand.

Fig. 7 is from a specimen of the Caddo, La., oil sand. This looks like a gray shale to the unaided eye, but it is a very fine-grained quartz sand, with little cementing material and very friable. Some 10,000-barrel wells were found in the same horizon and close by the well this sand came from.

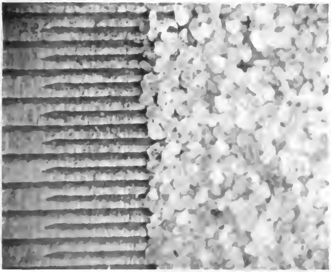


FIG. 4

Fig. 8 is from a specimen of Kansas gas sand from the B. Johnson farm south of Independence. It came from a well giving an initial open-flow capacity of 34,000,000 cubic feet per 24 hours. It is coarse grained, with but little cementing material.

Fig. 9 is from a specimen of salt from Belle Isle, La. When such salt is drilled into the cuttings, when bailed from the well, if held on a shovel in fresh water, will pop and snap like pop-corn, the reason being that the oil and gas in the bubbles are under high tension and, as the enclosing walls of salt dissolve and so weaken, the bubbles burst. The salt is not, therefore, properly a "sand" or a reservoir rock, altho containing both oil and gas.

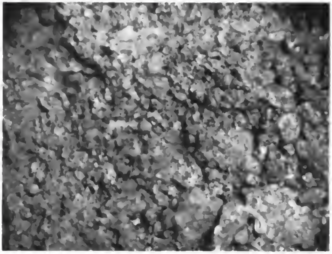


FIG. 5

Vast quantities of oil and gas and other bituminous material are imprisoned in various ways in the crust of the earth, but it is only when fortuitous circumstances have formed reservoir rocks that paying petroleum deposits occur. Oil and gas sands occasionally appear at the surface.

Fig. 10—view near Rogers Mount, Wyo. Over the man shown is an oil sand cropping which indicates approximately the pitch of the sand at that point. At his feet is an oil seepage hardened by long exposure to be almost like oven coke. By following the seepage to the foot of the hill as much as 20 acres of maltha occurs. There was also some gas escaping with salt and sulphur water.

Fig. 11—cropping of asphalt near Whittier, Calif. This asphalt was dug for fuel and stored to make smudge fires with when nearby orange orchards were threatened with frost. Also a slight seepage of oil may be observed running down the face of the asphalt near the center of the figure.

Fig. 12—cropping Colinga, Calif., oil sand. Of course the gas that was in these exposed rocks has long since escaped.

Croppings and surface showings of sands are indications that oil or gas may be found in paying quantity whenever that particular horizon has a sufficient impervious covering to seal them in and preserve them.

Note.—A short digression from the main subject is here made to say something on the mobility of oil and gas in the earth as affecting its ownership.

FIG. 6

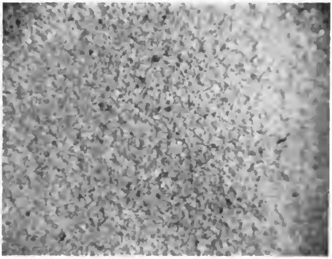


FIG. 7

FIG. 8

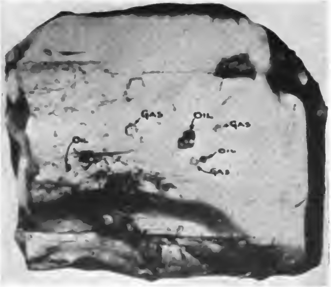


FIG. 9

Classification.

Oil and gas are classified as minerals and are judicially treated as such. (See the law relating to oil and gas by Thornton and others.)

Ownership.

The owner of the surface is the owner of the gas and oil beneath it. They are the subject of grant or conveyance, as much so as the grant or conveyance of any other interest in the same real estate. A reservation of "all mines, minerals, and metals in and under" a tract of land is a reservation of the oil and gas.

Compared with Wild Animals.

In seeking for analogous conditions in the law, courts have compared natural gas and oil to that of wild animals (*feræ naturæ*). "Water and oil," said the Supreme Court of Pennsylvania, "and, still more strongly, gas, may be classified by themselves, if the analogy be not too fanciful, as minerals *feræ naturæ*." In common with animals, and unlike other minerals, they have the power and tendency to escape without the volition of the owner. Their fugitive and wandering existence within the limits of a particular tract is uncertain. They belong to the owner of the land and are part of it, and are subject to his control; but when they escape and go into other land, or come under another's control, the title of the former owner is gone. Possession of the land, therefore, is not necessarily possession of the gas or of the oil.

When Title Vests in Owner.

It has been decided repeatedly by the courts that the owner of the soil owns the oil and gas beneath its surface. This is an acknowledgment of the absolute ownership of the oil and gas beneath the surface by the owner of the land. But under the Indiana decisions, which have met with the approval of the Supreme Court of the United States, the owner of the land has only a qualified right to the oil and gas beneath the surface. The right to reduce it to possession and to exclude all others from exercising the right does not hold until he has reduced it to actual possession, either by bringing it into a well, into a pipe line, or into a tank in case of oil. Until that has happened, the gas or oil by natural forces may escape from his land, be reduced to possession of another, and become his property.

Oil and Gas Leases.

Oil and gas leases are a part by themselves, altho there is some resemblance in them to coal or solid mineral leases. The rights of the parties to a lease must be determined by the law of the state where the leased premises lie, altho it may be executed in another state.

An oil and gas lease is a contract for a consideration establishing a vested right to enter upon a definitely described parcel of land, for a determined period, to prospect for, reduce to possession, remove, and market oil or natural gas. The vested right is the crux of the whole matter, and it is immaterial whether the instrument creating it is called a "lease," "contract," "grant," or "deed of conveyance."

Definite royalties are stated for oil wells and either rentals or royalties for gas wells. If oil or gas is developed, then the lease continues as long as either may be produced in paying quantity. There are many requirements necessary to be stated in a lease to fully protect the interests of both parties under varying conditions and to meet various court decisions.

A mere lessee—one who has no interest in the land itself, as a grantee beneath the surface—does not acquire title to the oil or gas in the leased premises until it has been taken from the ground.

It was held at a very early period in the history of the production of oil, and still is held, that a man cannot be restrained by his abutting neighbor from drilling upon his own premises, altho he located his well within a few feet of the line and will necessarily drain the oil or gas from his neighbor's land, if any exists there.

FIG. 10

Oil and Gas an Article of Commerce.

Both oil and gas are articles of commerce when severed from the soil, not, however, while remaining in it. When gas is carried from state to state, it is an article of interstate commerce, tho carried in pipe lines, as much so as coal, iron ore, or any other mineral carried by wagon or railroad; and no greater restrictions can be laid upon it when carried in pipe lines than can be laid upon solid minerals severed from the soil, or any other article of commerce. The carriage of oil and gas beyond the boundaries of a state cannot be prohibited.

FIG. 11

Mobility of Oil and Gas a Hazard.

On account of the mobility of oil and gas in the ground the hazard in the business of producing them is much greater than that of producing solid minerals that are of themselves immovable. Coal or oil shale, for instance, can be estimated quite accurately as to the yield per acre in tons; also as to the cost of producing and marketing the products.

There is no feasible way of estimating in advance the quantity of oil in barrels per acre that may be recovered from any particular tract in any given field or pool prior to drilling and development.

RATE OF DEPRECIATION OF OIL WELLS

Wells in the Pennsylvania series of rocks are usually long lived, altho of small capacity. The rate of depreciation in yield of oil is variable. In one case, from reliable data extending over a period of three years, the rate of depreciation was found to be about 3 per cent. per month. This is approximately 30 per cent. per year.

Oil wells in unconsolidated materials are very erratic in their yields. They may gush 500 to 1000 barrels per hour for a few days and then go to salt water and be a total loss.

Mining oil is a very wasteful process, and it is doubtful if as much as 70 per cent. of the total is recovered under the very best circumstances. Always an unknowable part is left as residual in the ground. It is imprisoned in the minute pores of the rock, and the oil as a liquid adheres to the surface of the minute passages in the oil sands. To make an exact computation of the available supply of petroleum in any field is, of course, impossible.

ESTIMATING ON YIELD OF NATURAL GAS

Quite the opposite is true of gas, on account of its gaseous condition and ease of self-escape. Any residual gas left may be reduced to below atmospheric pressure by vacuum pumps. That is, gas having an original rock pressure of 600 pounds, or 40 atmospheres, may be produced so as to leave less than 3 per cent. in the ground.

To gas may be applied measurements and calculations not possible with any other mineral. If, for instance, in any given pool the original rock pressure was known to be 600 pounds (40 atmospheres) per square inch, and after a given period it was reduced by use to an average of 450 pounds (30 atmospheres), we are reasonably certain, by the laws of physics, that 25 per cent. of the gas has been taken out. If we have an approximate measure on the gas used, we can calculate at once the probable volume still available.

WASTE OF NATURAL GAS

Natural gas, because of its being invisible and practically inodorous, and also because of its property of self-escape, has been subjected to the most wanton and wilful waste of any of our natural resources. The total amount wasted may be said to be beyond computation. It has been too often regarded as a by-product of the oil fields of no special value.

GASOLINE FROM NATURAL GAS

A new interest has been taken in the production of natural gas since much of it has been found to carry gasoline in quantity sufficient for profitable extraction. In 1916 it is estimated over 2,000,000 barrels of gasoline came from this source, and it is possible that if all the natural gas now being produced was carefully treated, as much as 10,000,000 barrels of gasoline would be recovered in one year. The amount of gasoline obtainable from 1000 cubic feet of gas varies from a gallon or less up to eight gallons. Most of the large natural gas companies now "milk" their gas of the gasoline contents before delivering it to the consumer for fuel. This gasoline is of double importance, in that it can be blended with gasoline otherwise unsatisfactory for use in the automobile, and thus made into an acceptable motor spirit.

STATISTICS OF THE PRODUCTION OF PETROLEUM

The total production of crude petroleum in the United States and of the world from 1857 to date is practically four billion barrels.

The question of oil supply is one of the most important raised by the present world war. We have to date produced 60 per cent. of the world's supply. Dividing our production into periods, we have the following table:

Petroleum Produced in the United States

6 year period, 1859 to 1865	13 millions of barrels
10-year period, 1865 to 1875	61 millions of barrels
10-year period, 1875 to 1885	212 millions of barrels
10-year period, 1885 to 1895	420 millions of barrels
10-year period, 1895 to 1905	808 millions of barrels
10-year period, 1905 to 1915	2102 millions of barrels
Total	3616 millions of barrels

ESTIMATE ON FUTURE PRODUCTION OF PETROLEUM

Assuming that the production of the United States continues to about double in every ten-year period, as it has in the past 50 years, we should produce approximately, in the next three ten-year periods, as follows:

10-year period, 1915 to 1925	4200 millions of barrels
10-year period, 1925 to 1935	8400 millions of barrels
10-year period, 1935 to 1945	16800 millions of barrels

This means that in less than 20 years, at the assumed rate, the production of oil in the United States will approximate one billion barrels of oil per year, or as much as the total production in the first 45 years of the industry. It seems to be very doubtful if any such vast quantity of petroleum will ever be produced in any one year within the limits of the United States by present methods. It also seems reasonable to say that the maximum yield of crude petroleum in any one year will probably be reached inside of 20 years. After this maximum is reached we may expect a gradual decline of petroleum production from oil wells in the United States extending over a long period of years. There are vast areas of probable oil lands in other countries that will, from time to time, become available

FIG. 12

for future exploitation by drilling. It is reasonable to expect that the world's production and consumption will, before many years, exceed one billion barrels per year.

MAXIMUM PRODUCTION OF THE WORLD'S OIL WELLS

There are no data to warrant even an approximate prediction as to when the maximum world's production of petroleum from oil wells is likely to take place. It certainly will not occur in the near future.

OTHER SOURCES OF OIL

Hydrocarbon oils that may be used in place of the petroleums obtained by drilling wells into, and producing from, the accumulations that occur in the reservoir rocks can be obtained from other sources and in vast quantities. It has long been known that "oyle, pitch and tar" could be distilled from coals and certain kinds of stones; also, some gas and other products are obtained in such distillations.

OIL SHALES

Oil shales are sedimentary rocks that are consolidated from very finely pulverized materials, clay and mud, and present great varieties of texture and composition. Some are highly bituminous and may be profitably used for the production of a crude hydrocarbon, oil, ammonia, and gas by dry distillation. Occasionally some are found so rich in hydrocarbon that pieces can be lighted with a match and will burn with a bright flame. Their geology and occurrence are comparable with those of coal. The solid bituminous material in oil shale is called "kerogen." By destructive distillation this gives rise to crude shale oil.

METHOD OF PRODUCING OIL FROM SHALES

Oil shales have to be mined, crushed, and retorted to get the crude oil and other products. In this process some ammonium sulphate is produced, forming a valuable by-product, thus making available vast quantities of shale that could not otherwise be worked at a profit for their oil contents alone.

The treatment of crude shale oil is almost identical with that of crude petroleum.

THE SCOTCH SHALE OIL INDUSTRY

The shale oil industry was introduced into Scotland in about 1850 from France. It has there grown steadily in importance and output, as indicated by the following figures:

1873 output	524,000 tons of shale
1882 output	1,030,000 tons of shale
1888 output	2,076,000 tons of shale
1908 output	2,892,000 tons of shale
1913 output	3,280,000 tons of shale

The yield of crude oil from the Scotch shales in 1913 was about 72,160,000 gallons (Imperial) or 1,718,000 barrels (American), or not quite one-half a barrel per ton.

At the same time the yield of sulphate of ammonia was approximately 300,000 tons. The mines and works afford employment to about 10,000 hands, and approximately $5,000,000 is paid in wages per annum. The Scotch shale oil industry is to-day paying dividends on a large investment.

The Scotch shales are now proving to be a valuable source of oil for the British Navy.

OIL SHALE OF THE UNITED STATES

Chiefly because petroleum has been cheap and abundant, the oil shale of the United States has received very little attention. There has, however, lately been some investigation of this mineral resource by the United States Geological Survey and the results have been given in its recent publications.

Bulletin 641-L gives the average thickness of the New Albany black shale in southwestern Indiana as being not far from 100 feet, and says: "It is a very moderate assumption to place the average thickness of the oil-yielding rock at, say, 30 feet, of which it might be possible to mine out one-half, or 15 feet. This shale underlies about 16,000 square miles. If 15 cubic feet of rock weighs one ton and yields 10 gallons of oil, 10 gallons of oil should be obtainable for every square foot of this area in southwestern Indiana. As a square mile contains roundly 28,000,000 square feet, the yield would be 280,000,000 gallons, or nearly 7,000,000 barrels to the square mile, or, say, 100,,000,000,000 barrels for the total area underlain by this shale in southwest Indiana."

Bulletin 641-F says: "In Colorado alone there is sufficient shale, in beds that are 3 feet or more thick and capable of yielding more oil than the average shale now mined in Scotland, to yield about 20,000,000,000 barrels of crude oil, from which 2,000,000,000 barrels of gasoline may be extracted by ordinary methods of refining, and in Utah there is probably an equal amount of shale just as rich."

Bulletin 641-L further says: "The black shales of the eastern states are mainly at one general horizon, in the upper Devonian, which extends from New York to Alabama and westward to the Mississippi River. Other extensive deposits of black shale occur in the same region at one or more horizons in the lower part of the Devonian and at one horizon in the Ordovician. In addition, black shales overlie some of the coal beds, especially certain beds in the eastern interior coal field."

GENERAL EXTENT OF SHALES CARRYING OIL-BEARING SEAMS

The quotations above given show the vast area covered by shale beds carrying workable seams of oil shales and their immense potential contents of oil.

When we consider that shale is found covering considerable areas between the Mississippi and the Pacific and in many other parts of the world, it is at once evident that the quantity of available oil stored as kerogen in shale is many times greater than that available as petroleum in the reservoir rocks and sands.

The extent in area and tonnage and yield in gallons per ton and pounds of sulphate of any given shale can be closely determined in advance, giving a certainty and stability to such enterprises not possible in a business dependent on the erratic yield of an oil field. The possibility of the kerogen in the shale changing ownership of itself in the manner of oil or gas would be out of the question. The fee of the land would be the absolute ownership of the included shale and its possible oil contents.

ESTABLISHMENT OF THE SHALE OIL INDUSTRY INTO THE UNITED STATES

As soon as our petroleum supply is depleted so that other sources of crude oil become a commercial necessity, the shale oil industry will then undoubtedly be established in the United States. Indeed, it is quite possible this industry could now be profitably undertaken at some strategic point, as for instance where a rich shale occurs and so situated as to be cheaply stripped and mined with a steam shovel, and with a nearby market for the products.

DISTILLATION OF COAL A GREAT SOURCE OF HYDROCARBON OIL

When the distillation of coal for the manufacture of illuminating gas was started, coal-tar began to be produced in quantity. It was at first regarded as a nuisance and allowed to run to waste. Afterward it was burned under the benches or the boilers at the gas works.

Coal-tar has since been the source of much chemical investigation, with the result that now the commercial importance of the "crude oils" obtained from it is almost beyond estimate. Its products include motor fuel, dyes, medicines, perfumes, explosives, essential oils, saccharine, etc., and the entire list now numbers many thousands of individual products.

In 1915 there were 4,665,000 tons of coal carbonized for the manufacture of coal gas in the old style of retorts. From 10 to 12 gallons of tar may be produced by this process per net ton of coal carbonized, and if the light oils are extracted from the gas, two gallons of light oil may also be saved. That is approximately 50,000,000 gallons of tar (1,200,000 barrels), and 9,330,000 gallons (225,000 barrels) of light oil were available from that amount of coal.

Also, in 1915, there were 19,554,000 net tons of coal carbonized in by-product ovens. The average yield per ton was 7.1 gallons of tar (138,733,000 gallons, or 3,300,000 barrels) and 1.54 gallons of benzol (30,000,000 gallons, or 710,000 barrels). (From Mineral Resources of the U. S.) Better results are now being obtained on the recovery of benzol.

Also, in 1915, there were over 40,000,000 tons of coal coked in the beehive ovens from which no by-products were recovered. This process requires a high grade of coal found in comparatively restricted areas of the total coal-bearing fields.

The development of the by-product oven has demonstrated that a superior coke for metallurgical purposes can be made by mixing coals of lower grade, thus vastly extending the area from which coals for coking may be obtained, and so the available future supply of hydrocarbon oils from this source is greatly increased.

The by-product oven yield of tar and benzol will depend largely on the volatile matter contained in the coal used. The yield may vary from 5 to 8 gallons of tar and 2 to 3 gallons of light oils per net ton of coal coked.

Prior to 1915 the market for by-products was small and the price low, so but few installations were equipped to recover all the light oils produced. In 1914 the value of the products recovered was less than $1,000,000. In 1915 the value was about $8,000,000.

This large increase in value was in a measure due to the installation of elaborate benzol-recovery systems that now save the valuable oils that not very long ago were burned or wasted, or, if saved, were begging for a market.

The present great incentive for building by-product ovens and putting in complete equipment for the full recovery of all products is in the opportunity to sell the toluol and benzol thus obtained at war prices.

It has, however, been demonstrated that better results can be obtained in the blast furnace from by-product coke made from medium-priced mixed coal than can be obtained from beehive coke made from the high-priced coking coal. Therefore, the future of the by-product oven is assured and the large financial investments necessary for the erection of by-product plants will be justified when peace again prevails.

We will probably see in the not distant future 100,000,000 tons of coal coked yearly in the United States in by-product ovens, from which we may expect a yield of over 700,000,000 gallons of tar (16,000,000 barrels) and about 250,000,000 gallons (6,000,000 barrels) of light oils. This will certainly be a notable increment to our total supply of hydrocarbon oils.

After the war the industries of the United States will control, in the coking of coal by the by-product method, a source of liquid hydrocarbons sufficient in quantity and quality to compete for and supply the world's demands for medicines, dyes, chemicals, and other coal-tar products.

Benzol has been proved valuable to mix with gasoline for use in the automobile, the mixture giving better results than the straight gasoline.

Alcohol is looked upon in some quarters as the ultimate fuel for small mobile internal-combustion engines. It is used now with difficulty on account of its high hydrogen content.

Commercial alcohol and gasoline are not miscible, but benzol and alcohol are miscible and make an efficient fuel, and, further, after the addition of benzol to alcohol the mixture will carry quite a high proportion of gasoline. The future may see benzol as the tie between gasoline and alcohol, permitting a piecing out of the gasoline supply and an introduction of alcohol as a commercial motor fuel. The normal price for benzol is about 20 cents per gallon. The present price is 50 cents per gallon; of toluol, $2.00 per gallon.

INCREASED CONSUMPTION OF GASOLINE

The automobile and other internal-combustion engines are primarily responsible for the increased consumption of gasoline.

The following figures indicate this increase in the number of automobiles used, based on state registration at the first of each year:

1899 (Est.)	10,000	1913	1,010,483
1905	85,000	1914	1,253,875
1910	400,000	1915	1,754,570
1911	600,000	1916	2,225,000
1912	677,000	1917 (Est.)	3,000,000

There are now about 4,210,000 motor vehicles in use in this country, of which approximately 400,000 are motor trucks.

In addition to this, we must take into consideration the gasoline powered motor boats, farm tractors, and the almost innumerable number of small gasoline motors in use for all manner of power purposes; also the gasoline used in the industries.

The cumulative horsepower of all the gasoline internal-combustion engines in the United States is estimated to be more than twice that of all the steam engines.

It is estimated the Government will require 1,000,000 gallons of gasoline per day for the use of the Army, Navy, and flying operations the coming year; also, that the total consumption will be about 6,750,000 gallons per day, or 55,000,000 barrels for the year.

It will require every effort of the oil producer and refiner to meet this vast demand.

GENERAL REVIEW

The facts given indicate that there were, during past periods of geologic time, vast stores of coal, oil, and kerogen of the shales deposited in the crust of the earth.

Among all the valuable gifts that Nature has bestowed upon man, these deposits, when properly used, are among the most essential to his well-being and progress. It is true that he could exist on earth under the beneficence of the sun's warmth and the fuel from the vegetation of the fields and forests, but it is clearly evident that to attain the best conditions of civilization and power he must have learned how to utilize these deposits of carbonaceous materials formed by the work of the sun during long periods of time in ages past.

The progress of civilization may well be measured by our ability to use the contents of these great storehouses of potential wealth for our comfort and convenience.

It is one of the most difficult facts of history to understand the extreme slowness with which the human race developed the industrial use of coal and the hydrocarbons. It is less than 200 years since coal was first used in an industrial way, about 100 years since the birth of the coal-gas industry giving us the coal-tars, and less than 70 years since shale oil was first produced in quantity. It is less than 60 years since the Drake well was drilled, and this gave birth to the petroleum industry of to-day.

SUMMARY ON COAL

We have enough coal to last for many generations to come, except, perhaps, of anthracite and some special grades of coking coal. This apparent shortage can be overcome by using coke made from lower grade coals in the by-product ovens. Of our total coal, about one-half of one per cent. has been mined.

A larger and larger supply of coal-tar and light oils will be available in the future as the coking of coal in the by-product oven is increased to meet the ever-growing demand.

SUMMARY ON OIL SHALE

The authority quoted on shale shows that large areas in the United States contain deposits carrying workable seams of oil shales, and their potential contents of available shale oil are immense and many times greater in quantity than that of the total available oil in the petroleum deposits.

We have the example of the established Scotch shale industry to follow, but the best methods of mining, crushing, and retorting our shales is yet to be worked out. There is no doubt but that a shale industry could be developed in the United States in a short time to supplement our supply of crude petroleum when this becomes commercially expedient, but is is hardly an emergency resource ready for immediate utilization.

If from a given seam of shale there could be produced per ton 20 gallons of crude oil, worth $8^{1}/_{3}$ cents per gallon, the present price of Pennsylvania crude at the well, and 25 pounds of sulphate of ammonia, worth at present prices 7 cents per pound, the total product per ton of shale would be worth $3.40.

An operation on a large scale should mine and retort the shale and pay interest and depreciation on the investment at a total cost of less than $2 per ton of shale treated. This would seem to be a very profitable operation under the conditions assumed.

SUMMARY ON PETROLEUM

The entire history of the discovery and exploitation of petroleum in this country has been full of surprises both to the practical oil man and to the geologist.

Soon after the discovery of petroleum in northwestern Pennsylvania it was established that the great reservoir rocks of this region were sandstones or conglomerates that belonged to the Devonian system. The conclusion was then reached by many that the natural home of petroleum was in the upper Devonian rocks. The overthrow of this premature generalization came from northwestern Ohio in 1884–1885 by the discovery of gas and oil in large amounts in the Trenton rock of the Silurian system, some thousands of feet lower in the geological scale than the upper Devonian. The inclusion of this lower horizon among the productive oil rocks of the country came as a great surprise to both the scientific and practical oil man. The Trenton rock has since yielded 540,000,000 barrels of crude oil.

In 1895 some petroleum had been produced at Neodesha, Kans., and was held in storage. In attempting to purchase some of it, the railroads would not at that time quote a freight rate on oil to be shipped in tank cars from this point. Before a meeting of the general freight agents of the railroads operating in that region it was stated that there was practically no oil in Kansas, and that all there was there could be shipped in barrels. The railroads did not want to haul tank cars, as they always went empty one way and could be used for but one class of freight.

Mr. J. D. Archibald, a president of the Standard Oil Company, testified in court that he once offered to drink all the oil got in the mid-continent field after his experts had first reported on it. Since those days this field has yielded above 600,000,000 barrels of oil.

In 1907 the Glenn pool in Oklahoma was found, and it is said to have touched a production of 100,000 barrels a day. This was at the time looked upon as the top-notch of any pool that would be found in the mid-continent field.

But in 1915 the Cushing field was found and the production touched 300,000 barrels per day from this pool. Million-barrel lots of this high-grade oil were sold for 29 cents per barrel at the well.

In 1901 the great Lucas gusher at Spindle Top, Texas, came in, gushing oil at the rate of fully 70,000 barrels per 24 hours. Previous to this discovery eminent geologists had reported the formation at Spindle Top was entirely too recent to expect to find oil there: that there was no precedent for it. This great discovery was a startling surprise to everybody, and it alone has produced over 40,000,000 barrels of oil since.

Judging from the past, it is reasonable to expect there may be in the future many more surprises of various kinds in the way of oil discoveries.

We are now producing petroleum at the rate of 312,000,000 barrels and using it at the rate of 330,000,000 barrels per year. We have 160,000,000 barrels in stock. But for the shortage of labor and casing this oil shortage would be quickly overcome, the present prices for crude being an inducement to drill and produce. We have used up 4,000,000,000 barrels, and it is estimated 8,000,000,000 remains in the ground.

SUMMARY ON GASOLINE

The requirements for gasoline are now at the rate of 55,000,000 barrels per year (2,310,000,000 gallons). It is difficult to see where this is all to come from. Improvements in refining and increased yield from natural gas will help out. A very large saving can be made by cutting out useless running of automobiles, spilling gasoline, leakages and poor adjustments of the carburetors, etc. The increase as expected with the cutting out of avoidable wastes will keep us from a gasoline famine. As a patriotic duty, joy-riding and using 10 cents' worth of gasoline to deliver a nickel's worth of groceries must be stopped.

No commercially practicable substitute for gasoline as a motor fuel has yet been discovered—benzol being too high-priced—nor can it be expected that one will be made available in time to assist the United States and its Allies in winning the war.

GENERAL SUMMARY

Our country is now overloaded with the direction of a great war for which it was not prepared and is not trained. The oil producers and refiners have been trained by the experience of the past and have, as a body, heretofore met all the emergencies of the business and are meeting the present great emergency. Probably no other industry has striven harder to serve well the public than has the oil industry. It matters not where the motorist has driven his car along the highways of this country the past season, he has found close at hand a supply station fully meeting his needs for oil and at a fair price.

The conclusions are as follows:

First.—That this country will supply an increased amount of petroleum sufficient for our expanding needs for only a few years to come.

Second.—That we will in the not-distant future, possibly in 20 years, reach our maximum production of petroleum within the limits of the United States.

Third.—That the world's maximum production of petroleum is many years distant.

Fourth.—That our supply of petroleum will in the future be supplemented by shale oil and light oils from tar, so that there should never be any real danger of a hydrocarbon oil famine.

Final.—The title of the paper, "An Optimistic View of the Future Supply of Oil," is fully justified.

THE ELEMENTS AFFECTING RIDING QUALITIES OF A MOTOR VEHICLE

"SPRINGS"*

By WALTER C. KEYS

PERFECTION SPRING DIVISION OF THE STANDARD PARTS COMPANY OF CLEVELAND

AT this meeting on "Springs" we want to find out for the society and for the industry just what can be accomplished by *springs themselves*, in so far as is known to-day in the art of *designing* and *building* springs, in bettering the riding qualities of a motor vehicle. Under the heading of design of springs, there will be two subheadings: First, The Type of Springs (Full-elliptic, Semi-elliptic, Platform, Cantilever, etc.); and, second, The Design of the Spring Itself. This second subheading would have to do with the spring being made up of a few and heavy leaves or many thin leaves. Also, we would be told, in connection with this second subheading, the advantage of broad and more or less flat springs in minimizing side sway, etc.

Springs and suspensions are interesting because elusive. There are no formulæ and data which are easily workable for the inexperienced engineer.

As to type of suspension, much can and doubtless will be said. The tendency in American design is now strongly toward semi-elliptic construction for both front and rear springs.

The best known and most generally used spring suspensions are semi-elliptic, three-quarter-elliptic, full-elliptic, three-quarter platform, full cantilever, one-quarter cantilever, and single cross spring. These types are so familiar to us all that a description of them is unnecessary. Each type has its own good points, and some types are especially applicable to certain cars. But each type must be correctly worked out for any particular car in order to give satisfaction.

Some years ago an advertising campaign was conducted by a certain company to educate the layman to believe that the underslung frame gave the best type of chassis that had yet been produced. Many reasons were offered. A few other companies followed with underslung construction, and many people believed that the whole industry would follow this precedent. We now know that the underslung construction is, for practical reasons, *not* superior to the overhung frame. It is not now used by *any large* manufacturer of gasoline cars in the United States.

Similarly we saw the bevel-gear drive come, being properly heralded by such cars as the old "Silent Northern." But for practical reasons we did *not* abandon the bevel drive and return to the chain, because we learned that a properly designed and built bevel-gear axle gave far better satisfaction than the old noisy chain, which could not be protected from mud and grit and which was always having to be replaced.

Two or three years ago we heard a good deal of talk about cantilever rear springs. Some engineers argued that the greater length of the full floating cantilever resulted in better riding qualities because of the slower period of vibration which was possible. Much publicity was given to this type of spring by those who adopted it. The public has *learned convincingly* that there is no *outstanding superiority* of riding qualities of those cars which are equipped with cantilever springs. There are very few men who could pick out a cantilever suspension, judging by riding qualities only.

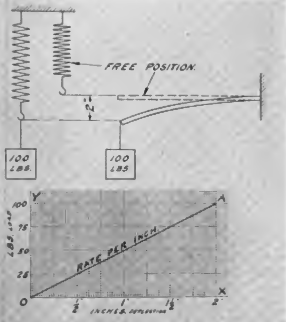


Fig 1.

None of us will ever forget the rides we have had over a corduroy road in a jolt wagon. Traveling at slow speed, with no springs of any sort, every unevenness of the road is followed by the wheels and the wagon body. This is one extreme.

The other is the modern automobile, equipped with large *tires*, properly designed *springs*, and properly designed *cushions*. Each of these three elements plays a very important part in giving the passenger the comfortable ride which he enjoys.

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* Presented before Pennsylvania Section, Society Automotive Engineers, October 25, 1917, at the Engineers' Club.

Tires are depressed by the smaller obstacles, an inch or two in height. The springs take care of the larger bumps and depressions in the road—*within limits*, of course. Cushions, if properly designed, also greatly aid in reducing the jar which passengers receive from rough roads, and, furthermore, they absorb many small vibrations of the car frame which would otherwise be quite annoying.

The principal function of the chassis spring is to store up and pay out energy. For this purpose the most generally used type is the so-called elliptic spring. In this, a series of flat plates are bent from the shape they assume when free, to some other form, as load is applied.

In Fig. 1 take each plate separately and load it as a cantiliver beam, or take the spring as a whole and apply load to it; we find that the deflection increases practically *directly* as the load is applied. In other words, the load-deflection curve is a straight line, and the energy stored up by deflecting the spring a number of inches, *OX*, under a load of *OY*, is represented by the area of the triangle *OXA*. This is *fundamental* and applies whether the spring is a cantilever beam, a coil spring in either tension, compression, or torsion.

To word it more broadly, we may say that if it takes 100 pounds to *bend or twist* a piece of steel a certain amount, it will take 200 pounds to bend or twist it twice that amount, working within the elastic limit of the material.

Now this law which applies to one flat leaf spring also applies to two which are coupled together, as in the case of a three-quarter elliptic or full-elliptic spring. Therefore no great difference should be found in the riding qualities of an automobile as we change from one type of suspension to another, other things being practically the same. That this is true is attested by the variety of suspensions which have been in use in the United States for the past ten years. If any one type had consistently shown its universal superiority, car builders would have been forced to adopt it, just as they were forced to adopt bevel-gear rear axles.

Fig. 2 shows five hypothetical cars which are fairly typical of the cars on the American market to-day. The dimensions of the springs are such as we have found to give good results. The loads and rates per inch are, of course, approximate only. The semi-elliptic spring front and rear is chosen because this type of suspension is simple from both the spring maker's and car builder's standpoint, especially if the Hotchkiss drive is used.

In developing any suspension we *must* at every stage keep the work *practical*. In order to accomplish this, we must know the various processes of manufacture of the spring, and we must know the use to which the spring will be put. The spring lengths, widths and thickness of plates must be worked out practically, giving due consideration to weight of car, total deflections, flexibility, etc. There is no way of arriving at consistently good results in laying out suspensions other than to use good judgment, based on records or knowledge of numerous good suspensions in past or present use. Compilations of such records are generally carefully guarded by spring engineers, to whom they are especially valuable.

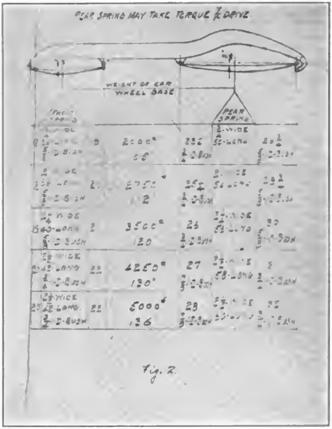

Fig. 2.

A very large number of the automobiles in America are driven most of the time on fairly good roads or pavements. There are times, however, when roads and weather are bad and the driver is in a hurry. It is then that springs are called on to give their maximum service. No man can have the proper respect for the springs on his car until he has ridden at high speed over rough roads full of bad ruts. The side strains on springs are enormous, and, while you brace yourself to keep from being thrown from one side of the car to the other, you wonder how those springs under you can be strong to hold the axles and frame together.

Fig. 3 shows a large touring car just alighting from a forty-foot broad jump, taken at a speed of fifty miles an hour. This is rather extreme, but nevertheless the chassis springs must be capable of standing up under such unusual conditions.

One of the important functions of the rear springs is that of taking the driving and braking strains. In the case of Hotchkiss drives they must also withstand the axle torque due to driving and braking. Familiarity with these requirements enables the engineer to furnish springs which are practical from the standpoint of manufacture and performance.

Let us not forget that the sales manager wants things *practical* from his standpoint, too. He wants the car low, and that means small clearance between axle and frame; and *that* means *less* flexibility of the springs. He wants to have new talking points each year, so we must humor him when he demands a change from semi-elliptic to cantilever, or from full-elliptic to three-quarter platform.

FIG. 3

The curves in Fig. 4 are taken from two springs of the same length, width, and flexibility, but having different number of plates. These curves were made by applying varying loads, beginning at zero and increasing to a maximum of 1700 pounds, and then releasing load gradually to zero again. For each load applied the deflection is recorded. It is to be noted that when load is first released the spring does not recoil immediately and that there is a loop between the lines representing increase and decrease of load. This loop represents the damping effect of the interleaf friction.

If it were not for the damping caused by the plates of the springs, the friction of shackles and eye-bolts, the automobile would continue to bounce up and down a long time after striking a single bump. This damping effect is essential in good suspensions, and must, of necessity, be present to some extent in any suspension which could be worked out for practical use.

The springs on racing cars are always taped or provided with some dead metal between leaves to further damp their action. Many devices are now on the market and in general use which act solely as dampers to spring action.

The Perfection Spring Company, now one of the twelve divisions of The Standard Parts Company, some time ago brought out "thin leaf" springs which are composed of many thin leaves, having about the same flexibility as the regular springs, but having greater damping effect, as shown in Fig. 4, wherein it is to be noted that the loop or damping effect is greater for the twenty-leaf spring than for the ten-leaf spring.

THE SPRING ITSELF

Not a great deal can be done with the elliptic springs other than to design them with proper length and width and to use as large a number of plates as may be considered practical from the standpoint of weight, cost, and total thickness of spring.

In most cars the springs soon become rusty and for the most part are not kept in the well-lubricated condition in which they are sent out by the manufacturer. Rusty springs do not work as freely as well-lubricated springs. That is to say, the flexibility is slightly less and the damping effect is considerably greater.

A recent experiment performed with a set of old springs led me to the conclusion that by thoroly lubricating them the riding qualities were improved for driving on pavements where there were only slight irregularities. However, in driving over *rough roads* the riding qualities were less satisfactory because of the tendency of the car to continue bouncing after striking the big bumps.

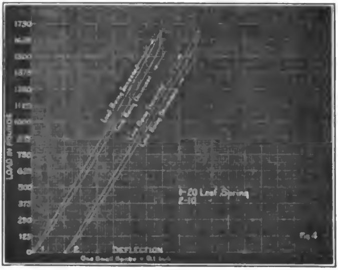

FIG. 4

RIDING QUALITIES

A few years ago the task was assigned of improving the riding qualities of a certain car owned by a man well known thruout the land. The car was equipped with a special closed body.

Considering every item which might be modified, the following changes were made: The pressure was reduced in tires. This did not cure the trouble. Second, softer chassis springs were substituted. Third, snubbers were added on the rear. These changes did not noticeably improve the riding qualities. The last move was to have all the upholstery in the cushion and seat-back opened up. Here the cause of the trouble was apparent, for the cushion springs were of makeshift construction, and evidenced a deplorable ignorance of the good and practical. Properly designed cushion springs were substituted, the cushions were provided with adequate air vents, and harsh riding qualities vanished.

ITEMS AFFECTING RIDING QUALITIES

1. Speed of car.
2. Flexibility of springs in relation to load carried.
3. Period of vibration.
4. Axle clearance.
5. Wheel base.
6. Size of wheel.
7. Size of tire.
8. Inflation pressure of tires.
9. Possibility of synchronism of period of front and rear springs.
10. Depth of cushion springs.
11. Period of vibration of passenger on cushion.
12. Position of passenger in relation to wheel base.
13. Location of center of gravity of car.
14. Relation of unsprung to sprung weight.
15. Flexibility of frame side members.
16. Shock absorbers.
17. Supplementary springs.
18. Spring inserts.
19. Effect of rebound straps.
20. Effect of torque at rear axle and at front of frame.
21. Eccentricity of spring.
22. Tightness of shackles and eye-bolts.
23. Gyroscopic action of rotating parts.
24. Condition of road.
25. Skill of driver in avoiding bumps and holes.
26. Ability of passenger to ride easily.
27. Clothing worn by passenger.

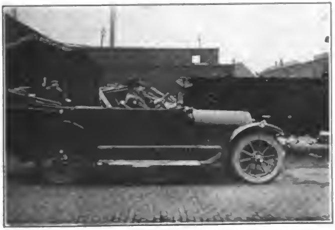

FIG. 5

Some time ago a well-known automobile engineer had some other engineers out for a trip. As he drove along over a fairly rough road he repeatedly called attention to the nice action of the springs, which were equipped with a certain auxiliary device. When they reached their destination they were invited to look at the new spring attachment, and in looking under the rear end of the car, to the amusement of all they found that the attachment was *not* on the car at all.

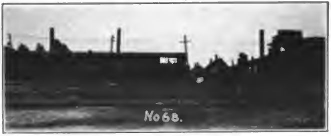

FIG. 6

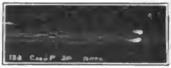

FIG. 7
Chevrolet Model, 3 passengers, 10 miles per hour

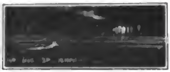

FIG. 8
Buick D-35, 3 passengers, 10 miles per hour

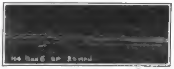

FIG. 9
Oakland 6, 3 passengers, 20 miles per hour

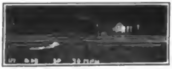

FIG. 10
Buick D-35, 3 passengers, 30 miles per hour

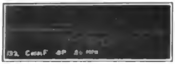

FIG. 11
Chevrolet Model F, 3 passengers, 30 miles per hour

RECORD OF RIDING QUALITIES

When first studying engineering work in connection with automobile suspensions, one is impressed with the great diversity of opinions regarding riding qualities, shock absorbers, etc. There has been need for some graph or record to prove, in addition to one's impressions, whether a certain shock absorber or auxiliary device tended to improve the riding qualities. Magazine advertisements and salesmen's talk might create a market, but they would not convince an engineer.

Fig. 5 illustrates a means of obtaining actual records. Electric lights are mounted on wheels, fenders, and passengers of an automobile, which is then driven at night in front of a camera.

Fig. 6 is a record made at twilight. The car was driven over the standard obstruction at about one mile per hour.

Figs. 7, 8, 9, 10, and 11 are records made by various cars under different conditions.

In closing it may be stated that in spite of the fact that the spring business has been shrouded in mystery, there really is no mystery about it.

THE ENGINEER IN THE CHEMICAL INDUSTRY

H. E. HOLLISTER, Member
CHEMICAL ENGINEER

THE engineer has become a popular subject of discussion, thanks to the general trend of public opinion, and we read and hear considerably more about him now than we did a few years ago. The scope of his work, the publicity given his accomplishments, and recognition by the public at large are becoming more extensive every day.

Engineers should try to increase publicity, especially that given by the newspapers, and at the same time endeavor to substantiate the correctness of statements published in the papers.

In the technical papers we read and discuss " His Relation to His Client," "His Position in Public Life," and those of us with a sense of humor are amused by the discussions we hear as to whether or not the engineer is professional if he accepts a salary. What is most interesting and encouraging is the view now taken by the newspapers of the many pieces of engineering work under construction and the interest manifested in them by the public.

Not many years ago the field of engineering work was very narrow. In connection with steel work, in the case of bridges, the engineers' services were considered necessary, but if a bridge was to be built of wood a carpenter was considered capable of designing it. Even buildings, regardless of their size or type, have seemed to the public the work for an architect rather than an engineer. This view is carried so far that the city of Chicago allows only a registered architect to design buildings built within its limits. Still, few architects are qualified to figure the stresses in a structure In fact, some of the most renowned of that profession would not appreciate being classed as an engineer. Again, when the engineer was referred to, people immediately thought of the locomotive engineer, or of the stationary engineer, and, if they considered him in any other light, it was as a surveyor. Even the business man's notion of the engineering profession or its scope was limited and narrow, and this was really the fault of the engineer himself. Either he did not know how or did not think it worth while to educate the people; he did not speak in the language they understood, and, further than that, he was too secretive.

Conditions have changed and the various branches of the profession are better understood and the importance of the engineers' work is more appreciated. Cities are finding it better to forget politics and put the water, street, and sewer departments in the hands of executive engineers, and some municipalities have gone so far as to place all city affairs under engineering managements.

The business man and the banker now have a better understanding of the engineer. There was a time when the lawyer was the first man consulted when business went wrong, but now the business man and the banker feel more toward a business as they would to their body. If they feel out of sorts, they conclude something must be wrong and consult a doctor. This is much more satisfactory than leaving the wrong go on or to take a dose of poison; so in business, when things go wrong they find an engineer and he locates the trouble and prescribes the remedy. The engineer in turn is learning how to present facts in a way that the business man understands.

You now find the engineer in many places that were not open to him a short time ago. He is, of course, found in mining operations, but you find him also in many branches of industry. The people and business men have opened their eyes to his ability, for it stands to reason that a man, to make a good engineer, must have a quick, accurate brain, must be original and creative, and be able to think quickly and clearly in an emergency, and with these qualifications and his ability for study and application, he is a valuable man, even outside his own profession.

One of the branches of the profession not so widely understood or advertised is the chemical engineer. Of course, in this country, he had little to discuss publicly until the war changed conditions. In Europe, especially in Germany, the engineer has been an important factor for some time past, but in America chemical works were small, were largely neglected by bankers, and did not seem to feel the need of engineering services. I do not mean there were no large chemical companies in this country or that they did not engage engineers, but it is a fact that the greater portion were small and could get along—especially if the chemist or superintendent had some degree of engineering ability.

If bankers had taken more interest and had invested more money they would have insisted on investigation by an engineer, but as matters went, except in some of the highly developed branches, they managed to get along without such services.

After the war began conditions changed greatly. Big opportunities in the present and future were seen by progressive concerns, capital became interested, companies combined, others started, and the busy life for the chemical engineer began.

Very few people realize or understand just where this country stood at the outbreak of war as regards chemicals, and few appreciate, even to professional men, the importance of the various chemicals in daily life. Perhaps, if there were a better understanding, more interest and importance would be attached to the chemical industry.

Clothes, food, and transportation, as well as light and, to some extent, heat, are all dependent on chemicals and the chemical industry. The Germans knew this and good-naturedly saved us the trouble of making many of the much-needed and important materials; in fact, according to some of their optimistic writers, they were sure the United States could not assist Germany's enemies to any extent, due to the fact that the shortage of chemicals would so cripple us that we would be in bad shape ourselves. They did not credit the American engineer or chemist with any brains.

What is the actual condition to-day? We are now making about everything required and of quality equal to anything ever imported. The quantity is in most cases satisfactory and in many cases larger than past supply.

How many have ever given the engineer credit for any of this development work? Even the chemist has been neglected. The people seem to feel that "We (meaning most any one) have made dyes," and their interest goes no further: the chemist and the engineer have done little to enlighten them.

All this development has been done under great handicap, much less data being available in this line than in other branches of the profession. Companies and individuals are secretive, and there is little with which to make comparison. There has not always been the heartiest coöperation between the chemist and the engineer, and this is very important for real success. Employers, due to the fear that their practice might become public, have kept information from the men they desired to develop their business and processes. Yet, thru it all, and with many handicaps, the industry has been placed in a position it never held before.

In the matter of acids we have improved processes, enlarged plants, and only for the large advance in price of labor and raw material could have reduced cost of production. Much larger quantities are being made with the same or less labor and with the same building space. The present production is much larger than that of four years ago, the greatly increased demand having been caused by the requirements for explosives and munitions. After the war, other uses for the greater part of it will be found, and, in fact, some firms are prepared for that now.

Many chemical salts are now made that heretofore were imported. Few people in watching a brakeman leave a train at night with his lantern and box of signal lights have known that the material for making these lights came only from Germany. At the beginning of the war a large signal-light manufacturer found himself in a bad position for lack of the strontium nitrate to make fuses. Celestite, a native rock, which is a sulphate, was available, but there was no known process by which pure strontium nitrate could be made from it, as the material must be absolutely pure. Several firms tried, but met with failure; one concern succeeded and the process was really simple.

Potash is still short, but the problem is being solved. It is now being obtained from various rocks as well as from sea-weeds, and also from the saline lakes of the West. Engineers have also invented processes to recover it from cement-mill and blast-furnace dust. We need a greater supply, but are doing well with what we have and the substitutes for it.

There are many developments that would be interesting to consider, but they could be discussed only in detail if taken up properly. However, it is safe to say that we are, and will continue to be, independent of any country for chemicals. There are still some raw materials we import, the most important of which is probably sodium nitrate, which comes only from Chile and is used for making nitric acid, but even this, if necessary, could be done away with by using any of the several processes for fixing atmospheric nitrogen; however, the nitre process is still the cheapest source of nitric acid known.

The question now is: "What will the chemical engineer do, as most developments have been made?" The industry has by no means been developed to the highest or even a satisfactory level. There is too much loss, too much waste, and manufacturing costs are too high.

In the words of *Topsy*, in our renowned "Uncle Tom's Cabin": "I'se just grew." So many of our chemical plants just grew. There is too much hand labor, units are sometimes too small, steam, water, and compressed air consumption is almost always too high, and there are many other bad points. In many cases manufacturing costs are not known. Cost-keeping systems are bad, and prices are set by guess; in other words, they need the doctor and should have him before the war ends, for prices and manufacturing costs are now too high to meet foreign conditions. The heavy taxes in foreign countries will help some, but we will also have our burden.

In Germany, according to an American consul, the large chemical companies which previous to the war carried on a foreign trade of about $214,000,000 have combined their foreign interests for the purpose of regaining the business they had previous to the war. These companies, which include the Badische Anilin and Sodafabrik, Hoechster Farbwerke, Leopold Cassella & Co., and others, are highly organized. Their production costs are naturally lower than ours, and they will probably use any means to regain their old markets.

We must save waste, reduce labor, improve the processes to the highest point of efficiency, utilize products now thrown away as waste, and lay out the plant as a whole so that the handling of raw and finished products is done with the least amount of labor. This does not necessarily mean a large expenditure of money or the shut-down of the plant. It is here the engineer is qualified to handle the situation.

Considerable has been done in the matter of utilizing waste materials. In some cases the new products are as valuable as the original materials. Millions of dollars are being thrown on the dump pile which should be saved.

There is still work for the chemical engineer and still an opportunity for him to continue the good work he has started. What he needs is the coöperation of the rest of the profession and as much publicity as possible.

ABSTRACT OF PAPER

AMERICAN PROGRESS IN PHARMACEUTICAL CHEMISTRY*

By ROBERT P. FISCHELIS, B.SC., PHAR.D.

H. K. MULFORD COMPANY, PHILADELPHIA.

THE progress of all branches of chemistry in this country since the beginning of the war has been remarkable, and the lay and scientific press has been filled with the wonders that American chemists have worked in the short space of three years.

There never was any question in the mind of those familiar with the subject as to the ability of American chemists to cope with the problems which have arisen in the past few years, but the opportunity to demonstrate this ability was not accorded the chemist until the advent of the war. It would take considerable space to relate all that has been accomplished by the pharmaceutical chemist in the last few years, but a few specific instances of American progress in pharmaceutical chemistry will no doubt be of interest.

While I am most familiar with the problems which have confronted our firm and what has been done to solve them, our experiences have doubtless been the same as those of other concerns in the same field.

The preparation of serums, serobacterins, and other biological products is dependent to a large extent upon organic chemicals; for instance, pure sugars, such as dextrose, lactose, and inulin, are required in the work of identifying different bacteria. These pure sugars formerly came from Europe, but when American supplies were cut off, our research laboratories were able to devise methods for producing these sugars in pure form on a commercial scale sufficient for our own needs and for supplying other laboratories.

Witte's peptone has long been the standard for the preparation of bouillon used in growing bacteria. Supplies of this essential article have also been cut off and it became necessary to make peptone. The peptone produced in this country thus far has not been as satisfactory as the one formerly imported, but it is good enough for most practical purposes. We have produced peptone in solution sufficient for our needs in the production of antitoxins, etc.

Another very important article required by the bacteriologist is three cresols, marketed by German firms under the name "Trikresol." Three cresols is used in the preservation of serum, bacterins, and other biological products because it has a high antiseptic value and is not poisonous in the sense that phenol is. It is not irritating to the tissues, and in the minute quantities needed for preservation of biological products has absolutely no effect when injected with the serum or serobacterin. While crude cresol and cresylic acid have been purchasable, the high degree of purity required by our bacteriological laboratories necessitated considerable research, resulting in a clear product which, according to our bacteriologists, is better than the product formerly imported.

In the strictly pharmaceutical field, the shortage of crude drugs has been felt more or less keenly ever since 1914. Fortunately, there were considerable quantities of badly needed crude drugs on hand in this country when the war began, and some have been cultivated, but the situation just at present is anything but comfortable. Stocks of many crude drugs have been exhausted, and the cultivation of medicinal plants has not yet assumed any great proportions in the United States. A great deal of misinformation and very little valuable information have been circulated by the public press on this topic. Two years ago the Pennsylvania Pharmaceutical Association issued a publicity bulletin calling attention to the possibilities of drug plant cultivation. Any number of letters were received from individuals all over the United States, asking for advice along this line; and one individual living in Mississippi wrote that she understood jimson weed was now bringing ten dollars an ounce; would we kindly give her exact information as to where to dispose of it, as she had nearly one-half acre available? A newspaper writer in the *Dayton* (Ohio) *Herald* gives the following advice to drug planters:

"'Camphor is now grown in Florida and Texas, the trees forming attractive hedges.' Who ever thought of camphor growing on trees? A hedge of green boughs laden with a luxuriant crop of camphor balls! How sweet the evening breeze from off that hedge! And how sanitary!

"Why can't this idea be extended in a profitable and beneficial manner? Put a quinine hedge either side of the front walk, with the capsules turned toward the flagging. Then plant climbing digitalis where it will clamber up the veranda pillars.

"Instead of sending small Raoul to the corner druggist, send him into the garden, when ill, to pick your favorite drug. Plant hardy listerine about the garbage can. Have a good, steady-bearing orchard of sweet cascara on one side of the house, and sow the corner lot to paregoric. Root up the old asparagus bed that never does anything, and substitute early aspirin. You will find that the aspirin will begin to flower about

---

* Read before the Philadelphia Section of the American Chemical Society at the Engineers' Club, November 15, 1917.

Decoration Day, and by the Fourth of July the first fresh aspirs will be ready to pluck. Probably you can check that Fourth of July headache with aspirin from your own garden, and, even if it doesn't prove altogether efficacious, you will have the satisfaction of knowing that it is pure, and that you raised it yourself in your own aspirin bed. This joy no one can take from you."

Let us consider for a moment the truth about the situation regarding medicinal plants. Those drugs which were obtained from Europe were not cultivated there, but grew wild. It was therefore a simple matter to have them picked and prepared for market, and the expense was comparatively slight. The cultivation of medicinal plants in the United States requires expert labor, the production of artificial conditions of soil and moisture in order to provide as nearly as possible the conditions under which the plants grow in their native habitat, and considerable investment of money. Drug plants have been raised on an experimental scale by the Government and in the drug gardens of various colleges, but it is a different proposition to raise them on a commercial scale. American growers of crude drugs were confronted with the necessity of increasing the value of the plants in order to overcome the high cost of cultivation. It was soon found that cross-pollination would not produce plants containing more active constituents than they do normally, but by careful selection of seed it has been possible to increase the amount of active constituents in such plants as belladonna, digitalis, etc., to three and four times what the Pharmacopœia requires. Furthermore, advanced methods of harvesting these plants have made it possible to secure three or four harvestings in one season, whereas in former years one or two was the limit.

Had it not been for the perfection of methods of standardization there would be danger in using drugs which are higher in their content of active principles than is normally required. But the fact that we have methods of standardizing these drugs, chemically or physiologically, or both, helps to make the cultivation of these drug plants with a high percentage of alkaloid an economic possibility. Here we have one instance of preparedness on the part of American manufacturers.

I was interested in an editorial appearing in the business section of the *Philadelphia Public Ledger* which called attention to the fact that dyestuff manufacturers are taking up the question of standardizing colors. The editorial writer stated that when the dyer knows a pound of green will produce the same shade and dye as much material, whether the maker be Brown or Jones, the American industry will have made a great step forward. The pharmaceutical industry long ago made this forward step, and it is now possible for physicians to feel satisfied that standardized tinctures, fluidextracts, extracts, etc., can always be depended upon for the same result under the same conditions when given in the same dose. Physiological and chemical assay methods have made this possible.

One very important line of chemical research relating to medicine and surgery that has grown out of the war has been the search for an ideal wound antiseptic.

Among the war antiseptics thus far devised are the Carrel-Dakin solution, Dichloramin-T (the name proposed by Doctor Dakin for the synthetic germicide chemically known as tolueneparasulphondichloramin), chlorazene (the name given to the sodium salt of paratoluenesulphochloramin), brilliant green, flavine, and similar dyes and various modifications of these.

The Carrel-Dakin solution is a solution of sodium hypochlorite, containing between 0.45 and 0.5 per cent. of sodium hypochlorite. If it contains less than 0.45 per cent., it is ineffective, and if it contains more than 0.5 per cent., it is too irritating. It is the outgrowth of considerable experimenting by Dakin, and the general opinion seems to be that where the Carrel technic of using this solution is properly carried out it gives excellent results.

The hypochlorites have long been known for their antiseptic value, and one objection to their use was the fact that they were irritating. Dakin overcame this difficulty by experimenting until he determined the strength of the solution at which its antiseptic value could be made use of without causing irritation. One difficulty with the preparation of this solution is the fact that chlorinated lime obtained from different sources varies in the percentage of available chlorine. This necessitates assaying the chlorinated lime and using different quantities of sodium carbonate and bicarbonate and requires titration in order to determine the percentage of hypochlorite in the finished product. If the solution is alkaline, it will harm the tissues. The general practice, therefore, has been to add phenolphthalein to the solution before it is used and, if found alkaline, neutralize the alkalinity with boric acid. Another difficulty is encountered here if too much boric acid is used. It is claimed that the sodium borate formed is also irritating to the tissues. Good results have been reported by surgeons who have used the concentrated hypochlorite solution which has been left slightly alkaline, but the alkalinity of which has been exactly determined, and an exact quantity of boric acid is furnished with the solution to neutralize the alkalinity before use.

In addition to being a strong antiseptic, Dakin's solution has the clinical advantage of being able to dissolve pus, old blood-clots, tissue-débris, etc. The action of this solution is based upon the fact that when hypochlorites or hypochlorous acid acts upon organic matter, of bacterial or other origin, some NH groups of proteins are converted into NCl groups. The products thus formed belong to the group of chloramines. Dakin states that the action of the solution is due to the chloramines thus formed and not to the liberation of free oxygen, as supposed by many. If the action were due to the liberation of free oxygen, such substances as hydrogen peroxide should have a higher bactericidal action than Dakin's solution, whereas ex-

(Continued on Page 54)

ENGINEERS' CLUB OF PHILADELPHIA

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LEWIS H. KENNEY, CHAIRMAN

REGULAR MEETING

At Witherspoon Hall, Wednesday, January 16, 1918, 8.15 P.M.

The address of the evening will be made by **Mr. Howard W. DuBois,** Member, on **"Alaska from an Engineer's Viewpoint."**

The paper will be illustrated with colored lantern slides and motion pictures.

Members of Affiliated Societies are cordially invited to attend.

Members of the Club and Affiliated Societies are privileged to invite ladies.

The special feature of the lecture will be a series of remarkable motion pictures, taken especially for the speaker during the past five years. These depict scenes connected with the building of the new Government railroad, copper mining, whaling industry, hydraulic gold mining, the birth of icebergs at the famous Childs Glacier, the great tidal wave at the head of Cook Inlet, hundreds of sea-lions leaping from the rocky islets into the ocean, the terrific eruption of Mt. Katmai, close-range views of the large moose and bear of the Kenai Peninsula, trips by dog-team, etc.

SPECIAL MEETING

At the Club House, Tuesday, January 29, 1918, 8.15 P.M.

The address of the evening will be made by **Prof. C. E. Lucke,** Civilian Director of the U. S. N. Gas Engine School, Columbia University, on **"The Heavy Oil Engine."**

PRELIMINARY ANNOUNCEMENT

Wednesday, February 6, 1918, 8.15 P.M., **at the Club House, Dr. R. S. MacElwee,** Columbia University, will present an address on **"Ports and Terminal Facilities."**

Friday, February 15, 1918, 8.15 P.M., **at Witherspoon Hall, Prof. Douglas W. Johnson,** Professor of Physiography, Columbia University, will present an address on **"The Influence of Topography upon the Strategy of the European War."**

The American Society Marine Draftsmen extends an invitation to the members of the Club to attend their meeting, Friday, January 11, 1918. **Mr. J. E. Freeman** will present an address on **"Concrete Ships."** The address will begin at 9 P. M., after a short business meeting.

CALENDAR OF REGULAR MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

1918

DAY OF MONTH AND WEEK	NAME OF SOCIETY
First Monday	**American Society of Civil Engineers** January 7, April 1.
Second Monday	**American Institute of Electrical Engineers** January 14, February 11, March 11, April 8, May 13, June 10.
Fourth Monday	**Philadelphia Safety Council** January 15, February 25, March 25, April 22, May 27, June 24.
Second Tuesday	**Engineers' Club (Junior Meeting)** January 8, February 12, March 12, April 9.
Third Tuesday	**Engineers' Club (except December, January and February)** March 19, April 16, May 21, June 18.
Fourth Tuesday	**American Society of Mechanical Engineers** January 22, February 26, March 26, April 23, May 28, June 25.
First Wednesday	**Technology Club** January 2, February 4, March 6, April 3, May 1, June 5.
Third Wednesday	**Engineers' Club (January)** January 16.
First Thursday	**Worcester Tech Club** January 3, February 7, March 7, April 4, May 2, June 6.
Second Thursday	**American Society of Heating and Ventilating Engineers** January 10, February 14, March 14, April 11, May 9, June 13.
Fourth Thursday	**Society of Automotive Engineers** January 24, February 28, March 28, April 25, May 23, June 27.
Third Friday	**Engineers' Club (February)** February 15.
Third Friday	**Illuminating Engineering Society** January 18, February 15, March 15, April 19, May 17, June 21.

Engineers' Club Meetings at Witherspoon Hall will be as follows:

Wednesday, January 16, **Engineers' Club** Meeting.
Friday, February 15, **Engineers' Club** Meeting.

Members of all Affiliated Societies are invited to these meetings.

SCHEDULE OF MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

JANUARY, 1918

Wednesday,	**January 2, 1918**	Technology Club of Philadelphia Discussion of plans for reunion of the Technology Clubs Associated	**Engineers' Club**	8.15 P.M.
Thursday,	**January 3, 1918**	Worcester Tech Club Address: "New York Catskill Mountain Water Supply" **Mr. Alfred D. Flinn**	**Engineers' Club**	8.15 P.M.
Monday,	**January 7, 1918**	American Society of Civil Engineers Annual Meeting	**Engineers' Club**	8.15 P.M.
Tuesday,	**January 8, 1918**	Junior Meeting Dinner—Addresses by **J. A. Vogleson** and **J. A. Steinmetz**	**Engineers' Club**	7.00 P.M.
Thursday,	**January 10, 1918**	American Society of Heating and Ventilating Engineers Subject: "The Modern Dairy" **Wm. H. Timm**	**Engineers' Club**	8.15 P.M.
Thursday,	**January 10, 1918**	Illuminating Engineering Society Joint meeting with The Franklin Institute Subject: "The Physics of the Welsbach Mantle" **Dr. Ives**	**Franklin Institute**	8.00 P.M.
Monday,	**January 14, 1918**	American Institute of Electrical Engineers Subject: "Specifications Covering the Construction at Crossings of Overhead Lines of Public Utilities" **Paul Spencer** **G. E. Wendle**	**Engineers' Club**	8.15 P.M.
Tuesday,	**January 15, 1918**	Philadelphia Safety Council Annual Meeting of Local Section	**Engineers' Club**	8.15 P.M.
Wednesday,	**January 16, 1918**	Regular Meeting Engineers' Club Address: "Alaska from an Engineer's Viewpoint" **Mr. Howard W. Du Bois**	**Witherspoon Hall**	8.15 P.M.
Tuesday,	**January 22, 1918**	American Society of Mechanical Engineers "Our Navy and the War" **Prof. William L. Cathcart,** U.S.N. (Retired)	**Engineers' Club**	8.15 P.M.
Thursday,	**January 24, 1918**	Society of Automotive Engineers Address: "Upholstery as Affecting Easy Riding"	**Engineers' Club**	8.15 P.M.
Tuesday,	**January 29, 1918**	Special Meeting Engineers' Club Address: "The Heavy Oil Engine" **Prof. C. E. Lucke**	**Engineers' Club**	8.15 P.M.

SECRETARY'S NOTICES

A BUSINESS MEETING of the Club will be held Wednesday evening, January 16, 1918, at 8.15 o'clock, at Witherspoon Hall. The report of the Tellers on the vote on amendment to the By-Laws, Article VII, Section 9 (new) will be announced.

H. A. STOCKLY, *Secretary.*

The Committee on Nominations will be glad to receive, prior to February 1, 1918, suggestions from members of the Club in connection with the election of officers for the coming year.

ABSTRACT OF MINUTES OF THE JOINT MEETING OF THE ENGINEERS' CLUB AND THE MANUFACTURERS' CLUB

HELD MONDAY EVENING, DECEMBER 10, 1917

The meeting was called to order at 9 P.M. by Mr. Alexander Lawrence, of the Manufacturers' Club, at its Club-house. About 500 members and guests of both clubs, including many officers and men in uniform, were in attendance.

Mr. Joseph A. Steinmetz introduced the speaker, Captain W. Strother Smith, U.S.N., who delivered an address entitled "Inventions Relative to War Material."

A unanimous vote of thanks was extended to the speaker.

The meeting adjourned at 10.15 P.M.

ABSTRACT OF MINUTES OF THE BUSINESS MEETING OF THE CLUB

HELD WEDNESDAY EVENING, DECEMBER 19, 1917

The meeting was called to order at 8.15 P.M. at Witherspoon Hall. About 1000 members and guests were present.

The minutes of the Special Meeting of November 9 and the Business Meeting of November 20, as printed in THE JOURNAL, were approved.

It was announced that the Board of Directors, at its last meeting, elected the following to membership: Active, 12; Junior, 36.

The proposed amendment to the By-Laws, as submitted to the membership at the December 11 meeting, was approved without change and ordered for letter ballot, in accordance with the provisions of Article XII of the By-Laws.

Mr. G. Douglas Wardrop, editor, *Aerial Age Weekly*, delivered a lecture, entitled "The War in the Air," illustrated with motion pictures and slides.

A unanimous vote of thanks was extended to Mr. Wardrop.

The meeting adjourned at 10 P.M.

ABSTRACTS OF MINUTES OF REGULAR MEETING OF THE BOARD OF DIRECTORS

DECEMBER 11, 1917

The meeting was called to order at 7.15 P.M., with President Vogleson, Vice-President Yarnall, Directors Fernald, Henderson, J. C. Wagner, Kenney, Moody, S. T. Wagner, Forstall, Bullens, Past Presidents Swaab and Ledoux, Treasurer Stevens and Secretary Stockly in attendance. Mr. Clayton W. Pike, chairman of the Committee on Increase of Membership, was also present, at the Board's invitation. Vice-President Andrews, Director George W. Barr, and Past President Carter were excused. Vice-President Eglin, Directors Hayward, Ehle, and Robert M. Barr were absent.

The minutes of the Regular Meeting of the Board of November 13 and the Special Meeting of November 27, as submitted to the Board, were approved.

REPORT OF THE SECRETARY

Resignations from the following members in good standing were presented and accepted as of March 31, 1918:

Murray B. Courtright
H. H. Demmert
A. C. Fisler
W. H. Ludwick
J. T. Swartz
Frank P. McKibben
George J. Ray
Irwin T. Reiter
J. C. Rock
Oscar C. Schmidt

The following deaths were announced:

A. Theodore Bruegel (Active Member), November 8, 1917.
Walter Lloyd Mason (Active Member), November 15, 1917.

It was decided that, in place of the Annual Banquet, this year, a housewarming smoker and dinner be held, to be arranged by the Committee on House.

Mr. D. A. Hegarty, who resigned as an Active member in good standing as of December 31, 1915, was reinstated on payment of dues which have accrued since his resignation.

Mr. L. Davis Draper was dropped from the rolls for non-payment of dues.

The Philadelphia Safety Council, local branch of the National Safety Council, has been elected to affiliation with the Club, in accordance with affirmative vote of the Board, taken by letter ballot.

REPORT OF THE TREASURER

The report of the auditors as of October 31, 1917, and the financial report for the month ending November 30, 1917, were presented and accepted.

REPORT OF THE COMMITTEE ON HOUSE

The Committee's report, announcing that "Open House" would be held, as usual, on New Year's Day, was presented and accepted.

REPORT OF THE COMMITTEE ON MEMBERSHIP

On the recommendation of the Committee, the following applicants were elected:

To *Active* Membership:

Craig Adair
Joseph H. Amies
Claude A. Bulkeley
Arthur Claassen, Jr.
Arthur C. Freeman
Frank Huckel, Jr.
Eugene T. Hunt
Harry A. Kaupp
Albert F. Noble
Victor N. Welamb
Frederick J. Wilkes
Richard F. Williams

To *Junior* Membership:

Arthur A. Blue
Frank F. Boettcher
Ralph Wherry Bye
George A. Cunney
Henry W. S. Deemer
Quintin F. Dickinson
James M. Doyle
Vernon Rea Dunlap
Harold M. Foster
Alexander Frank
David M. Giltinan
Henry F. Goldsmith
Maurice Golove
Louis LeRoy Hepburn
Richard P. Horner
Jacob R. Hoxworth
George B. Hutchinson
James A. Jensen
James E. McCambridge
Deacon T. McCaulley
Jerome S. Marcus
Allison W. Mills
Edward Paul Noppel
Louis A. J. Rabinowitz
William F. Rommel, 3rd
Samuel L. Schwartz
Meyer H. Silverman
Stanley W. Smith
Edgar K. Spring
Benjamin Stambler
George Bruce Staples
William A. Steiger
Jacob W. Stirzel
Lewis J. D. Truhall
Jacob A. Wilson
Louis A. Young

REPORT OF THE COMMITTEE ON PUBLICATION

A financial report of the Committee, showing an unexpended balance in its appropriation of $1206.86, was presented and accepted.

REPORTS OF SPECIAL COMMITTEES

Committee on Public Relations

The Committee presented a report, with the following recommendations, which the Board approved:

That a special committee be appointed to formulate, in connection with and in consultation with the local Fuel Administrator, some simple rules for eliminating the wastage of fuel and water. The Committee further recommends that these rules, when formulated, be published in The Journal, and, if possible, in the daily newspapers.

The Committee suggested that, thru the local Fuel Administration, the community be advised that, upon request, free services for cursory examinations would be furnished wherever possible by the engineers of our Club.

The Board referred the matter to the special committee to be appointed on this subject, with the further reference that the matter has been treated in the December issue of the *Journal of the American Society of Mechanical Engineers*, and stating that it was the expression of the Board that it should be ascertained whether there will be men available for this service before a definite offer is made.

The meeting adjourned at 9 P.M.

H. A. Stockly,
Secretary.

POSITION WANTED

Mechanical engineer, not liable to present conscription, desires position as engineer or assistant to manager. Twenty years' experience, familiar with present shop methods and productions, experienced designer capable of developing new lines. Not afraid of responsibility. Apply Engineers' Club, No. 180.

POSITION OPEN

Mechanical engineer and draftsman, experienced in boiler work. Apply Engineers' Club, No. 181-A.

Wanted.—A young man, technical graduate, with four or five years' factory experience, for position of assistant engineer. Good opportunity for advancement. Apply Engineers' Club, No. 183-A.

COMMITTEE ON MEMBERSHIP

D. ROBERT YARNALL, Chairman

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before January 7 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

PHILIP H. S. HANGEN

1231 West Silver Street, Philadelphia, Pa.

Assistant Sales Manager, C. J. Heppe & Son, Sixth and Thompson Streets, Philadelphia, Pa.

Proposed by Oswald M. Milligan and J. Reese Bailey.

STEWART ALEXANDER JELLETT, JR.

1718 Real Estate Trust Building, Philadelphia, Pa.

Vice-President, Stewart A. Jellett Company.

Proposed by Stewart A. Jellett, M. M. Price, and H. P. Gant.

CARL M. KIMBELL

140 North Fifteenth Street, Philadelphia, Pa.

Engineer Inspector, The Philadelphia Electric Company.

Proposed by Harold Goodwin, Jr., and H. Carl Albrecht.

ROBERT C. MORGAN

1718 Real Estate Trust Building, Philadelphia, Pa.

Chief Engineer, Stewart A. Jellett Company.

Proposed by Stewart A. Jellett, M. M. Price, and H. P. Gant.

JAMES A. NELSON

The Margrave, Twentieth and Chestnut Streets,
Philadelphia, Pa.

Assistant to Manager, Machinery Fabrication Department, American International Shipbuilding Corporation.

Proposed by H. L. McMillan and George E. Lawrence.

ROBERT CARL RAHM

1125 Belmont Avenue, Wyomissing, Pa.

Chief Engineer, Textile Machine Works.

Proposed by George F. Ott and James A. Branegan.

VICTOR JAMISON ROBERTS

110 Hardenbrook Avenue, Jamaica, N. Y.

Transitman, New York Connecting Railroad Company.

Proposed by C. Raymond Larkin and John F. Rowland.

FELIX JOSEPH WASILKOWSKI

3489 Jasper Street, Philadelphia, Pa.

Mechanical Engineer, David Lupton's Sons Company.

Proposed by Joah Brogden and John H. Thornton.

FOR ELECTION TO JUNIOR MEMBERSHIP

ROBERT CLEELAND

5020 Race Street, Philadelphia, Pa.

Sales Engineer, Perkins & Co.

Proposed by W. M. Boehm and Lewis H. Kenney.

AUGUST H. HEINE

1314 Spruce Street, Philadelphia, Pa.

Engineering Assistant, Bell Telephone Company of Pennsylvania

Proposed by W. M. Boehm and Lewis H. Kenney.

HARMAN MARTIN MOLONY

2427 North Fifty-fourth Street, Philadelphia, Pa.

Engineering Assistant in Outside Plant Department, Bell Telephone Company.

Proposed by W. M. Boehm and L. H. Kenney.

ROBERT LINWOOD SATTERWHITE, JR.

4107 Walnut Street, Philadelphia, Pa.

American International Shipping Corporation.

Proposed by W. M. Boehm and Lewis H. Kenney.

GEORGE GORDON URQUHART

4217 Pine Street, Philadelphia, Pa.

Foreman, Debenzolizing Plant, U. G. I. Company, Thirty-first Street and Passyunk Avenue, Philadelphia, Pa.

Proposed by W. M. Boehm and Lewis H. Kenney.

RAYMOND WEST WILKINSON

2830 North Marshall Street, Philadelphia, Pa.

Engineer's Assistant in Outside Plant, Bell Telephone Company.

Proposed by W. M. Boehm and L. H. Kenney.

JUNIOR SECTION

Dr. Wm. Boehm, Chairman *Ex-Officio* H. I. Goldstein, Chairman A. B. Bishop, Secretary

THE regular monthly meeting of the Junior Section was held Tuesday evening, December 11, 1917, Chairman H. I. Goldstein presiding. About forty members and guests were present.

The various committees presented short verbal reports:

For the Committee on Papers, Chairman Kline reported that Mr. W. W. Pickles will present a paper at the February meeting on "Health Engineering."

Attention was called to the annual competition for the Junior Prize, offered by the Club. Those interested are referred to the August PROCEEDINGS, page 380, for further information regarding the competition.

For the Committee on Meetings, Chairman de Macedo described the work started to keep accurate records of attendance by means of card-index and "tagging" system. In order still further to increase the attendance, a change of the meeting night had been suggested, but Mr. de Macedo reports that on consultation with the secretary of the Club, this was found impossible. The Committee will keep this point in mind when the 1918–1919 program is up for consideration.

For the Committee on Membership, Chairman Goldsmith reported that applications for Junior Membership were still being received and would probably be acted upon in January.

For the Club and Public Relations Committee, Chairman Godsho requested the chairmen of the various Junior committees to have reports in the hands of the secretary at least by the night of the regular monthly meeting, as it is necessary to complete the copy for the JOURNAL by the 15th of each month. This committee is at all times glad to receive communications from any Junior on matters of interest to the Club.

Chairman Pickles, of the Committee on Entertainment, announced that arrangements for the second annual dinner of the Junior Section, on the 8th of January, were well under way, and a really enjoyable and worth-while evening's entertainment may be expected. No Junior member should fail to be present. The program will be made up of several addresses by Senior members, greetings from Juniors in the national service, and numbers touching upon the lighter side will have prominent place. Details are not at present available, but will be sent out together with the invitations.

Attention was also called to the fact that nineteen of their fellow members were in the service. He suggested that the Juniors, as a body, send each of these men a Christmas token in the form of "smokes," accompanied by a formal letter conveying the Christmas and New Year's greetings of the Section. A formal motion asking for contributions from those present was carried, and a sufficient sum was realized to carry out the plan proposed.

After the conclusion of business, Mr. L. M. Goldsmith read a paper on "The Measurement of the Flow of Liquids and Gases in Pipes." The paper was illustrated and later discussed by Messrs. Bittel, Kline, Kennedy, and Spitzglass.

At the conclusion of the discussion Dr. W. M. Boehm, on the behalf of the Club, landed the good work of the old Junior Committee in the recent membership campaign, and as a token of appreciation he presented each member of this committee with a Club pin. Mr. Godsho then expressed the thanks of the Committee for the honor conferred, and in return presented Doctor Boehm with a Club pin on the part of the Executive Committee as an appreciation of his interest in all matters pertaining to the Junior Section.

The meeting adjourned at 10.20 P.M.

Standing committee assignments were announced as follows:

Executive Committee.—H. I. Goldstein, chairman; A. B. Bishop, secretary; A. P. Godsho, L. M. Goldsmith, W. Z. Kline, A. de Macedo, W. W. Pickles.

Club and Public Relations.—A. P. Godsho, chairman; M. G. Bittel, J. A. Jensen.

Papers.—W. Z. Kline, chairman; E. M. Bredin, M. M. Kennedy, L. Zoole.

Meetings.—A. de Macedo, chairman; H. B. Floyd, R. W. Hendee.

Membership.—L. M. Goldsmith, chairman; A. de Macedo, H. F. Goldsmith.

Entertainment.—W. W. Pickles, chairman; E. M. Bredin, J. S. Marcus.

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, Chairman

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF DECEMBER 20, 1917

NAME	RANK	CORPS	LOCATION
Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Chattanooga, Tenn.
Anders, D. W.	Captain	Company D, 502nd Engineers	Overseas Service
Andrews, J. H. M.	Major	103rd Engineers	Washington, D. C.
Asplundth, E. T.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Atterbury, W. W.	Brigadier-General	Director-General of Railways	France
Barker, E. W., Jr.		Truck 4–304 Ammunition Train	Camp Meade, Admiral, Md.
Bates, A. J.	Lieutenant	111th Infantry	Camp Hancock, Augusta, Ga.
Bear, H. K.	Private	Gas Defense Service	Washington, D. C.
Bell, Frank F.	1st Lieutenant	Signal Corps, Aviation Station	Gerstner Field, Lake Charles, Louisiana
Biester, W. H., Jr.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Booz, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	France
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. F.	1st Lieutenant	U. S. Naval Reserve	U. S. S. "Jupiter"
Boyd, G.	1st Sergeant	Overseas Repair Section No. 1	Gas Defense Service, Medical Corps
Bradford, J. S.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Bransome, E. D.		Mass. Inst. Technology Aviation Camp	Boston, Mass.
Bream, C. C.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Breen, J. W.	Captain	23rd Engineers	Camp Meade, Admiral, Md.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Broadhead, Alex.		19th Reserve Engineers	American Expeditionary Forces, France
Broderick, D. F.	Major	Ordnance Officers' Reserve Corps	Rock Island Arsenal, Rockland, Ill.
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, France
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	2nd Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.		Carriage Division, F. A. Section	Washington, D. C.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Childs, H. P.		7th Infantry, Reserve Officers' Training Camp	Ft. Myer. Va.
Colgan, R. J	Captain	American Expeditionary Forces	Care of Adjutant-Gen'l, Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	Camp Hancock, Augusta, Ga.
Crowther, E. C.	Corporal	Jefferson Hospital Unit	
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Albemarle Bldg., New York
Cutler, James B.		Reserve Officers' Training Camp	Fort Oglethorpe, Chattanooga, Tenn.
Dill, C. M.		Company K, 319th Infantry	Camp Lee, Petersburg, Va.
Donnelly, J. B.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Doyle, T. H.	2nd Lieutenant	Quartermaster Officers' Reserve	Camp Meade, Md.
Dunn, M. L.	Ensign	Reserve Officers' Quarters	U. S. Naval Academy, Annapolis, Md.
Dyson, C. W.	Captain	Bureau of Steam Engineering, U. S. N.	Washington, D. C.
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.
Elcock, Chas.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Everett, St. John	1st Lieutenant	Coast Artillery Reserve Corps	Fort du Pont, Delaware

Farr, Roy S.	2nd Lieutenant	301st Engineers' Train	Camp Devens, Ayer, Mass.
Faust, W. D.		103rd Engineers	Camp Hancock, Augusta, Ga.
Fenton, Powell		Aviation Corps	France
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	Philadelphia Navy Yard
Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	Washington, D. C.
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	Washington, D. C.
Gauthier, Jordan	2nd Lieutenant	Provisional Searchlight Detachment	Washington, D. C.
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American University, Washington, D. C.
Getz, Ralph P.		19th Reserve Engineers	American Expeditionary Forces, France
Gillan, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Gilpin, F. H.	Inspector of Ordnance	Research Laboratory, Picatinny Arsenal	Dover, N. J.
Gracey, A. L.	Private	Ordnance Officers' Reserve	Watervliet Arsenal
Gravell, W. H.	Captain	305th Engineer Regiment	Camp Lee, Petersburg, Va.
Gribbel, W. G.	Captain	30th Engineers	Overseas Service
Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C.
Gwilliam, Mark R. M.	1st Lieutenant	21st U. S. Infantry	San Diego, California
Hall, W. A.	Lieutenant	Naval Coast Defense	Philadelphia Navy Yard
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	103rd Engineers	Camp Sevier, Greenville, S. C.
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hathaway, H. K.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Haydock, Roger			
Henry, J. C.		Headquarters Dep't 19th Reserve Engineers	American Expeditionary Forces, France
Hetherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Infantry	Charlotte, Ga.
Hollenback, E. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.		Division Headquarters	Camp Hancock, Augusta, Ga.
Houwen, W. P.		Section Headquarters, United States Navy	Lewes, Delaware
Hulme, Norman	Lieutenant	Co. 4, Engineer Officers' Training Camp	Fort Leavenworth, Kansas
Jones, Jonathan	Captain	23rd Regiment Engineers	Camp Meade, Md.
Kennedy, J. H.		Aviation Section, Signal Corps	American Expeditionary Forces, France
Kern, F. X.	Lieutenant	23rd Regiment Engineers	Camp Meade, Md.
Kneass, E.	Ensign	U. S. Naval Academy	Annapolis, Md.
Knight, C. C., Jr.	Lieutenant	81st Division, Field Artillery	Camp Jackson, S. C.
Knowles, Morris		4th National Army Division Cantonment	Admiral, Md.
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	American Expeditionary Forces, France
Lawrence, G. E.	Lieutenant J. G.	Naval Coast Defense	Philadelphia Navy Yard
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Levin, J.		2nd Officers' Training Camp	Fortress Monroe, Va.
Lewis, J. C.		Engineer Officers' Reserve Corps	France
Ludwick, W. H.		United States Coast Guard	Avon-by-the-Sea, New Jersey
Lynch, N. L.		Engineer Officers' Reserve Corps	Washington Barracks, Washington, D. C.
Magee, J. W.	2nd Lieutenant	306th Engineers' Corps	Camp Lee, Petersburg, Va.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Maburry, W. G., Jr.		6th Battery, Officers' Reserve Training Camp	Chattanooga, Tenn.
McCausland, J. R.	Master Engineer	446th Engineers, Depot Detachment	Camp Devens, Ayer, Mass.
McClintock, J. L.		U. S. Navy Radio Service	Parkway Bldg. *pro tem.*
McCord, J. B.	Captain	Ordnance Officers' Reserve	War Department, Washington, D. C.
McCoy, J. F.		Aviation Section, Signal Corps	Princeton, N. J.
McGarrigle, J. J.		2nd Officers' Training Camp	Fortress Monroe, Va.
McMillan, H. L.	Captain	Engineer Officers' Reserve Corps	Camp Dix, Wrightstown, N. J.
Millar, E. A., Jr.	1st Lieutenant	Ordnance Officers' Reserve	Camp Hancock, Augusta, Ga.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Chattanooga, Tenn.
Moon, T. E.	Private	Ordnance Department	Augusta Arsenal, Augusta, Ga.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.

Myers, W. C.	Captain	Ordnance Officers' Reserve	Washington, D. C.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	Captain	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixon-Miller, M.	Captain	Company "B," 501st Engineers	Camp Merritt, N. J.
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
Oakes, J. C.	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Otwell, Curtis W.	Colonel	104th Engineers	Camp McClellan, Anniston, Ala.
Perry, Edward		Quartermaster Officers' Reserve	Camp Lee, Petersburg, Va.
Peterman, J. M.	Private		Camp Meade, Admiral, Md.
Peters, E. T.	Yeoman	U. S. Navy	Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Prichett, F. B.		First Troop, Phila. City Cavalry	Camp Hancock, Augusta, Ga.
Pugh, M. R.	Major	21st Engineers	Camp Grant, Rockford, Illinois
Rawcliffe, J. F. B.	Lieutenant	Field Artillery	Houston, Texas
Reed, R. W.	Private	19th Reserve Engineers	American Expeditionary Forces, France
Reed, Thomas	Captain	Ordnance Officers' Reserve Corps	Rock Island, Illinois
Reninger, H. A.	Major & Adjutant, A.G. Dept.	53rd Depot Brigade	Camp Hancock, Augusta, Ga.
Ridge, R. S.	Sergeant	23rd Engineers	Camp Meade, Admiral, Md.
Ridgway, J. J.	1st Lieutenant	Co. F, 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.		Electrical Research Dept., Aviation Section, Signal Corps	Mineola, L. I.
Roof, J. C.	Captain	17th Engineers	France
Roth, F. E.	Private	316th Infantry	Camp Meade, Admiral, Md.
Rust, E. P.	Lieutenant	U. S. N. (Chief Engineer)	U. S. S. "Sealia"
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Sauter, W. R	1st Lieutenant	Ordnance Officers' Reserve	Washington, D. C.
Schmidt, A. H.		Company "C," 315th Infantry	Camp Meade, Admiral, Md.
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Smith, W. S.	Captain	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	Overseas Service
Spencer, Alex. G.		Royal Flying Corps	Toronto, Canada
Spillan, J. J. D.	Sergeant	Hq. 53, Brig. F. A.	Camp Hancock, Augusta, Ga.
Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	1st Lieutenant	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Engineer Officers' Training Camp	Belvoir, Va
Thacher, C. H.	2nd Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
Thomas, R. S.	Captain	Engineer Depot	Eagle Pass, Texas
Thomson, H. A.		Quartermaster Officers' Reserve	Camp Hancock, Augusta, Ga.
Tillson, P. E.	Lieutenant	Naval Coast Defense	Philadelphia Navy Yard
Vaughan, D. L.	1st Lieutenant	Officers' Reserve Corps	Camp Joseph E. Johnston, Jacksonville, Fla.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	Camp Grant, Rockford, Illinois
Warfel, J. P.	Senior Lieutement	U. S. Naval Reserve Force	Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	Engineer Officers' Reserve Corps	France
White, W. M.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C.	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	C. A. C. School D	Fort Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Camp Wheeler, Macon, Ga.
Zinn, George A.	Colonel	District Engineers' Office, Custom House	Portland, Oregon
Wentz, E. M.	Asst. Paymaster	Receiving Ship	Brooklyn Navy Yard

REQUEST FOR INFORMATION

THE COMMITTEE REQUESTS THAT THE MEMBERS OF THE CLUB INFORM THE COMMITTEE OF THEIR ADMISSION TO THE MILITARY OR NAVAL SERVICE.

THE COMMITTEE WOULD ALSO BE PLEASED TO RECEIVE SUGGESTIONS FROM MEMBERS WHO HAVE ENTERED THE SERVICE.

PLEASE ADDRESS COMMUNICATIONS TO THE COMMITTEE ON NATIONAL SERVICE.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS ∴ PHILADELPHIA SECTION

Lewis F. Moody, Chairman. John P. Mudd, Secretary, Midvale Steel Company, Nicetown, Pa.

MEETING IN NOVEMBER

A MEETING of the Philadelphia Section of The American Society of Mechanical Engineers was held at the Engineers' Club, No. 1317 Spruce Street, Tuesday evening, November 27, Mr. Lewis F. Moody presiding.

The meeting was opened with a statement of the progress being made by the various sections by Mr. D. Robt. Yarnall, chairman of the National Committee on Sections. The fact was emphasized that some of the newer western sections are extremely active and progressive.

Following Mr. Yarnall's talk, Mr. Ernest Hartford, secretary of the Committee on Sections, talked upon the subject of section activities in an endeavor to impress upon the Section the necessity for activity in procuring good technical papers for use in the *A. S. M. E. Journal.*

A motion was made by Mr. L. H. Kenney and carried directing that the Chairman appoint a committee on papers.

Prof. Walter Rautenstrauch gave the leading paper of the evening, entitled, "Manufacturing in Relation to Banking, Research, and Management." This paper will subsequently be published in full in The Engineers' Club Journal. A rising vote of thanks was given to Professor Rautenstrauch.

MEETING IN JANUARY

On January 22 Prof. William L. Cathcart, United States Navy (retired), will address the Section on the subject, "Our Navy and the War."

The meeting will be held in the Engineers' Club's auditorium.

Members of the Philadelphia Section of the Illuminating Engineering Society have been invited to this meeting. The lecture will be fully illustrated.

ILLUMINATING ENGINEERING SOCIETY
PHILADELPHIA SECTION

Walton Forstall, Chairman Unit Rasin, Secretary, 1411 Widener Bldg.

THE next meeting of the Philadelphia Section will be a joint meeting with The Franklin Institute on Thursday, January 10, 1918. The subject will be "The Physics of the Welsbach Mantle," by Doctor Ives.

The December meeting occurred on the 21st, in The Franklin Institute, and was opened by Mr. Howard Gyon, who continued his talk begun the previous month on lighting units and their significance, with special reference to the unit solid angle, lumens, and candle-power.

Miss Beatrice Irwin, of New York, spoke on the subject of "Color Science in Illumination." The basis of her discourse was the consideration that heretofore color has been accorded a negative and purely ornamental status in our consciousness and expression, whereas it should be considered a dynamic force, subject to classification and correspondence as exact and multiple as those accorded to sound. Just as there may be physical, mental, and nervous effects thru other causes, so color may soothe, refresh, or stimulate. Therefore, according to Miss Irwin's nomenclature, color is classified as sedative, recuperative, or stimulant, according to the effect. It was stated that observation and laboratory tests have proved such results, but the application requires a finer distinction in shades of color rather than a reference to a given color in general.

The speaker then exhibited a number of light filters, consisting of specially painted parchments, designed to surround a light-source as a shade. The color of the pigments, as well as the design, determined the color classification of the effect. Needless to say, the results desired were effects and not illumination efficiency.

Miss Irwin made a plea for more and better color effects, not only in outdoor architecture, as evidenced by the Panama Pacific Exposition, but also in offices and homes.

PHILADELPHIA SAFETY COUNCIL

LOCAL SECTION No. 7 OF NATIONAL SAFETY COUNCIL

M. W. Rudderow, Acting President

J. P. Mudd, Secretary-Treasurer,
The Midvale Steel Co., P. O. Box 1322

MEETING IN NOVEMBER

AT the meeting on November 27, Mr. H. W. Forster, Manager of The Independence Bureau, delivered a very excellent paper on the subject, "Industrial Housing, Its Relation to Accident Prevention."

This paper is published in full on page 18 of this issue of the JOURNAL.

ANNUAL MEETING

The annual meeting of The Local Section will be held in The Engineers' Club's auditorium, 1317 Spruce Street, on January 15, 1918.

At this meeting the election of officers for the following year will take place. Mr. Rudderow, acting president, has appointed a committee, consisting of Francis D. Patterson, Coleman Sellers, Jr., J. F. Conner, C. C. Black, and D. N. Frazier, as a nominating committee. The recommendations of this committee will be published to the membership at the same time that the notices are sent out for the January meeting.

TECHNOLOGY CLUB OF PHILADELPHIA

H. A. Terrell, President.

N. A. White, Secretary, Wenonah, N. J.

THE next meeting of the Technology Club will be held on Wednesday evening, January 2, 1918. There will be an informal dinner at 6.30 P.M. and meeting at 8.15 P.M.

Plans for the reunion of the Technology Clubs Associated will be discussed, and the work of the various committees will be outlined.

The reunion will probably be held on March 29 and 30, with headquarters at Drexel Institute.

A tentative program has been arranged and will soon be ready for publication.

In view of the present war conditions, a program of exceptional benefit and service is being arranged, and expenses will be reduced as much as practicable.

The following Executive Committee has been appointed:

Dr. Hollis Godfrey, President
EXECUTIVE COMMITTEE
Herbert A. Terrell, Chairman
D. K. Bullens, Finance and Treasurer
Charles F. Willard, Publicity
J. Peterson Ryder, Registration
Claude A. Anderson, Hotels
Hiram L. Walker, Transportation
Nathaniel A. White, Secretary

As the representatives of the various Technology Clubs will be guests of the Philadelphia Club, the active coöperation and assistance of all members is necessary.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ∴ PHILADELPHIA SECTION

Nathan Hayward, Chairman

H. Mouradian, Secretary, 1631 Arch Street

JANUARY MEETING

THE January meeting of the Philadelphia Section will be held in the auditorium of the Engineers' Club, Monday, January 14, at 8 P.M.

The speakers will be Mr. Paul Spencer, of the United Gas Improvement Company, and Mr. G. E. Wendle, of the Lycoming Edison Company, of Williamsport.

The subject of the meeting will be "Specifications Covering the Construction at Crossings of Overhead Lines of Public Utilities."

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-2 FEBRUARY, 1918 NO. 159

THE WORK AND EXPERIENCES OF THE UNITED STATES ENGINEER TROOPS IN FRANCE*

By MAJOR-GENERAL CHARLES M. CLEMENT, U.S.A.†

IN the first place, I ought to apologize for being a physical derelict. Meeting a reporter on one of your newspapers to-day, he said, "You cannot be General Clement: I am looking for an invalid." Between the two physical examinations the Secretary of War courteously granted me I was examined by a civilian physician and was again examined to-day; nobody but an army doctor can find anything the matter with me. I can still dance until four o'clock in the morning. Of the twelve generals that went to France in the same party, I was the only one that was out every bit of the time assigned to us to examine and study the situation over there. However, it is not up to me or anybody else to criticize the Government at this time. I agree with the Secretary of War that sixty-two years are an insuperable barrier to efficient service abroad. Of course, naturally, I thought myself an exception to that rule.

Before coming to the subject, I want to say a word about your own and our own division—the Keystone Division—and particularly about the 103d Engineers, formerly the First Pennsylvania Engineers, of which Company B was largely organized. The 103d Engineers was most fortunate in securing for its commanding officer Lieut. Col. Fred A. Snyder, who for three years had been a lecturer on engineering in the Canadian War College.

The work done in this organization has been truly wonderful. Every type of military bridge has been constructed, and in one case, where the bridge was improperly put up and fell down, Colonel Snyder insisted that it should be left there as an object lesson to all others. Every type of trench constructed on the European front has been duplicated in the instruction series; tunnels, saps, and counter-mines have been built, so that there is better opportunity for the student than at any school I visited on either front.

The instruction thus given has been taken up and assimilated by the officers in other regiments who are engineers by profession, with the result that all the engineering work in the two infantry brigades is approaching the standard set by the 103d Engineers.

In the 110th Infantry there was a most elaborate system of entrenchments with a definite plan of attack. It was assumed that a row of houses about three-fourths of a mile distant were occupied by enemy sharpshooters, and sniper posts were established, so carefully camouflaged with old cans that I was on the point of reprimanding the commanding officer for using his trenches as a dump, when I casually discovered that several of these cans were simply designed as protection to rifle barrels and the rest to mislead the enemy as it had misled me. The major of this regiment, coming from the western part of the state, was assuring me that they could do this work so well because they were from the bituminous coal region; looking down into a twenty-foot trench, it struck me the men working there were not from the western part of the state, and I asked, "Boys, where are you from?" "Sir, we are all from Philadelphia."

Other regiments visited showed a like degree of proficiency and a careful comprehension of the object to be attained thru "trench warfare." The officers in charge were able to give lucid explanations both to the men at work and to the Commanding General, all of which satisfied me that, so far as engineering instruction was concerned, the infantry brigades had received all the instruction that was needed on this side of the Atlantic.

From the standpoint of military engineering, I have no hesitation in saying that the Pennsylvania artillery brigade is entirely fit to go to France to-morrow and can do any work; that their guns were as well concealed as any I saw on the French battle front, without any artificial camouflage. Of course, there is a little more timber here than in that country. I heartily favor compulsory military service. I have never been in favor of universal military service, but am willing to admit that in a country the size of this there must be selection, and those should be taken who can play the game with the least possible loss—but it should be compulsory. However, in a volunteer force like ours there is a set of men one-half of whom are playing the game because it is a game in which we want to win, and, after all, that is what counts.

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* Presented before the Philadelphia Association of Members of the American Society of Civil Engineers, January 7, 1918, at the Engineers' Club.

† General Clement, lately commander of the 28th Division, U. S. A., Camp Hancock, Augusta, Ga., has just returned from the firing line in France, where he made a thoro study of the war situation.

In the profession of engineering, the engineer who plays his game because he wants to win has a broader imagination, a quicker comprehension of the thing that is to be done than the man that plods along under the book and the red-tape rules that handicap any profession. You will find, as time goes on, there will be no contribution to the fighting forces in France that will excel in spirit and determination the men of the 28th Division. Since I have been home a young man walked into my office, who had on his sleeve the insignia of a sergeant of ordnance. I congratulated him on his promotion, but I said, "Do you know the risk you are taking?" He said, "Oh, yes; but I don't want my family to know it." He said, "I thoroly understand that when an ordnance dump is hit we will all be sent home in boxes, but let us play the game." That is the underlying spirit that will bring success—a determination to play the game for success—and that, you will find, is the spirit that actuates the major portion of the division that represents this city and state at Augusta, Ga. That division has not figured very much in the papers because there have been no complaints; it has not figured much in the papers because it has a negligible sick list; it has not figured much because thru the foresight of General Stewart it went equipped and none of the men have been suffering for lack of equipment. It is ready to go across, and let us in imagination cross over ahead of it and see if we can picture some of the things that confront it. It is not my business to discourage people; it is my business to encourage them. It can be said concisely of this war in Europe that it is no place for a nervous woman or a homesick man. It demands the best, mentally and physically, that everybody contains. As a result of the three years' struggle entirely new data have been evolved and much of the engineering work in military science, as almost everything else in war, has been relegated to the scrap heap.

I will try to present to you in a brief way some of the fundamental difficulties confronting the engineers and the way in which they have been handled. The Allied forces had no common unit of measurement. The first difficulty that met the engineer officers of the French and English armies was to devise a system of maps to get over that difficulty without any hope of teaching the ordinary soldier or officer how to reduce yards to meters and kilometers to miles—to make a map that, once printed, would be perfectly serviceable in every army. And they have worked out a perfect scheme that ignores any idea of yards, feet, meters, or miles, and coördinates everything on fractions alone. The maps are made on scales that are universally 1/2500, 1/10,000, 1/40,000. When a man sees that map, whether he can read it in meters or yards it matters not, he reads all that is on it to his understanding, which is all that is necessary. The old cumbersome ways of designating routes have also been overcome by the engineer. The old army rule that required a general to put in his order, spelling out in Roman capitals, the names of all towns and roads, needlessly prolonging the order, is abolished by this system of maps. All of France has been mapped in a section of sheets numbered from one up. Each sheet is divided into a number of squares, and they are all exactly alike in number. Each square is again subdivided into four principal parts; so that when a man receives an order to do a certain thing he is referred to sheet one, No. 27, and one of the four subdivisions, which are designated by the first four letters of the alphabet. For the very simple reason that men speaking different languages cannot and do not pronounce the first four letters of the alphabet alike, they have substituted arbitrary symbols to represent them; so that C, which can be hissed over every tongue, is the only one of the four letters which remains as it was. "A" is "ah." "B" is "beer"—I suppose all engineers are familiar with that—and "D" is "don." I found most men said "damn." The sections are divided that way, and if they want to locate a cannon they may mark one of these, subdivided, "I-don-19, sheet 6," and they send that to the battery commander and he can locate it within fifty feet. Such messages can be sent by wireless or wig-wagged from an aeroplane. It is a high triumph of military art. By the substitution of the new system for the old, whether the reader be an Englishman, a Frenchman, an Italian, or even an American, the map means just the same to him. It used to be that a map was handed to a regimental commander and by him passed to a battalion commander and upon that map he formulated his orders. It is not so to-day. The map goes into the hands of the squad leader, because the science is so changed that the fighting is not done by the commanding general. His work is to see that his men are kept healthy, well fed and well equipped, and held to the highest type of discipline. The fighting is done by the squad leaders and company commanders. The men who do the fighting must be intelligently taught what they have to do. The bayonet positively thinks in this war. It was not until the British and French soldiers learned that the bayonet must think that they became effective, so they are changing their past defeat into present victory, and are gathering strength which must inevitably carry them across the Rhine, unless there is a collapse in Germany before that day comes. When I started studying military science we were awakened in the night and told to issue an order. Once that order went out it became the basis of the movement of the forces under you. Commanding a provisional brigade several times I had to work up those orders, and was impressed with the fact that if I were fighting I would have little chance to get out whole, because there was too big a field to look at. It is all changed now. They make up their minds to attack a certain point, the commander dictates to the engineers the thing he has in his mind, and the chief of engineers goes out and produces on the ground to a perfect scale a map of the whole country that has to be traversed in that engagement.

In the fight on the Messines Ridge, where I had an opportunity to study each map—nearly six months were required preparing the map, as I called it—or the plan—on the ground, of the region to be traversed. The aeroplanes took their photographs every day—both the panoramic photograph out of the sides of the machine and flat photographs from the bottom. These were read by the microscope, printed by the photographer, and then sent to the engineer to be worked up not only on the practical map that goes to the men but on this outline by which they were to learn to read their maps. You may have seen the French magazine called *Illustracion* depicting a large map around which was a railing and a platform, on which the commanders and officers could study this map as it grew from day to day and familiarize themselves with the piece of ground that was going to be covered in an attack. In the preparation for that attack, which took nearly six months, every woods, every house, every tree was marked, and if they discovered that they had made a mistake and a better photograph showed an error, it was corrected and everybody brought back to study that part again. Here was a new development of military engineering by the aid of photography and the aeroplane. The English engineers coördinated and put upon the ground an exact picture of the area occupied by the German Army, and when the time came to move they moved irresistibly over the lines laid down, to complete victory, because every man engaged had in his mind his primary object, his secondary object, and the ultimate object of attack, and worked with an intelligence that had been unknown.

Victory will come in this war to the best-educated men. It is not the aeroplane, the submarine, the hand grenade, or bomb that is going to win, but the brains of the soldier plus his confidence in his rifle and his bayonet. That is why I feel that the advent of the American soldier will give it triumphant victory, because we are sending thinking men in the ranks, and the officers who can see the problem will win it with the same determination that an American wins any game in which he engages.

The study of that field of fire over the Messines Ridge was a revelation to me of the discipline of engineering. The patience displayed in reducing fifteen miles in length and six miles in depth to a scale that could be put on a field of about 1000 feet by 2500 feet, and put on so accurately that when the order came thru in the morning to move forward every man could find his path as surely as if he were on Broad Street under a row of electric lights, was indeed wonderful. Each man had completely absorbed the surroundings. He had taken in all that the engineer had done and was able to carry it out.

When I first went over I was assigned to the First Anzac Corps. Like Pennsylvanians, they are volunteers. They are entirely independent of the British War Office. The Parliament of Australia consented to put men in this war with the understanding that the commanding general should make all appointments to office and he alone should decide who should remain and who should go back. Having prescribed these conditions, they elected Lieutenant General Birdwood, a British officer of the Indian Army, to represent them, and, altho he had never been an Australian, he was so loyal to his trust that the Commonwealth of Australia sent the best she had to be represented in that fighting corps. They are the same kind of volunteers we are in Pennsylvania, and they have gone in with a determination to win. Their engineering force has contributed to this war what is known as the "duck board," which when the Canadians saw it named it the "bath mat." I asked why it was called a "duck board," and they said it was because it did not keep them out of the mud. The Canadians called it a "bath mat" because when you are on it you don't take a bath. In Flanders the ground is covered with about three feet of mud, and if you get off this "duck board" you are up to your knees instantly, and the Australians worked out this scheme to enable them to go against the Germans irresistibly. The "board" is constructed of a number of small strips of wood, fourteen to fifteen inches long, and nailed to stringers; these are placed one in front of another until there are miles of it to walk on. Over that line the soldier, the donkey, and the mule went to victory. It would have been impossible to do it in any other way thru the mud.

There are no trenches in that part of Flanders. When you go to dig a trench you are waist deep in water. If it rains only twice a day in Flanders it is considered a clear day. I never wore woollens or woollen underwear in my life until I landed in Paris, and it was so cold that I started to buy some. I bought three suits of underwear and three pairs of socks. When I asked the price, it was $40 good American money. That shows the importance of equipping your soldier with the socks, underwear, and the sweaters he needs, and realizing that the Government cannot meet that demand. If your boy is over there or going over there, make sure he has an abundance of those things, because without them he will become a sure victim of pneumonia. When I visited the Johns Hopkins unit I said to Howard Kelley, "Major, what percentage of your cases are venereal troubles?" And he replied, "None, sir." I said, "Do you mean to tell me that venereal diseases are unknown here?" He said, "Yes, sir; we have none in the American army." I then asked, "Well, what is it?" And he replied, "All respiratory troubles, due to wet feet, improperly clothed, improper underwear, and all absolutely preventable." The American people should realize it is necessary for them to furnish these soldiers with the necessary clothing, and that it is not a Government function—or, if it is, the Government cannot meet it—and every man must be equipped with these things.

After I left the Passchendaele front—and may I say just one more thing about it?—there is only one set of forts in France which stood this bombardment, and they were built by Vauban in the early days of the seventeenth century, in the city of Ypres, where everything has been destroyed. Great Britain should buy this city and fence it in as a terrible monument of hate. The only things standing are the forts that Vauban built, and in the damp forts two British commanders have lived, or at least existed, during all the months that warfare was going on at the Ridge. Rheumatism and rheumatism medicine are everywhere. No one has any business in one of those places that ever had rheumatism in his life, and no man goes there who does not sooner or later contract rheumatism. One of the cheerful sounds you hear when you step outside of one of those casements is the shells whistling over your head.

I do not think I saw a man in Europe that had any fear of death. I have seen men who had fear of being blinded or of losing both legs, but I met no man that looked upon death as any terror. The elevation of this war—the comprehension that the liberty of the world is absolutely at stake—has so raised the hearts and minds of the British and French soldiers and our American contingent that there is no thought of death anywhere. Should you speak to a man about the danger of death, he looks at you and smiles. That is the last of the things he thinks about; he gives it no consideration. Day by day he marches by the flower-decked graves along the roadside—and they are kept decked with flowers all the while by the Belgian and French women—and he is as bright and cheerful as the flowers on those graves. But he draws back at the thought of being blinded. The German hate that pours out liquid fire is repulsive to him, but the death that comes in legitimate fighting is an incident of the game of the men that constitute those armies. It was not so at the beginning; it has been a process of education until the average soldier in all those forces is fully persuaded that he can look four boches in the face and get away with the four. I have seen a British sergeant defy four men to come to him with bayonets, and I have seen him disarm them with his naked hand, when he knew a slip of that hand would mean a severe wound, if not death, to himself. He was teaching those men to be fearless, and he had to be fearless himself. He kept that up and challenged one fellow to try to go at him in real earnest, and he got so angry I thought he would break his bones when the General said they would have to stop, as he saw they were losing their temper.

They had arranged to pull off a raid on Sunday, October 13. I had gone out on the 12th of October and studied this polygon which showed how far the soldiers were to go and where to stop and they were not to go a bit farther. They had thoroly mapped it out. It was to be pulled off at 5:45 and everybody had been so instructed. Fortunately they picked up a German prisoner and they found on him an instruction to be on the lookout for an attack at that time. German spies had contributed that information to their staff. General Scott never said a word. I asked him no questions and he gave me no information, but at 4:45 in the morning he directed that the fight start at 5:15; the boches were caught asleep and they had to fight without breakfast, and the Germans will not fight without breakfast, so they captured all they did not kill. They have to capture some now; they have to get over their desire not to take prisoners. They have to do it for this reason: they must have the German prisoner write back home how well he is fed by the English—and there is no censorship on the prisoner's mail. That gets back to the starving wife and family, and it has what the politicians call to-day a "psychological" effect; that is a new name for it. It applies to everything. So they take prisoners. However, taking prisoners is not the whole object. When I studied army tactics some years ago we had five points, represented by the five fingers of our hand, and there was nothing said about killing anybody. But an army order to-day reads: "The object of this attack is (*a*) to kill the Germans; (*b*) to reach hill number so-and-so; (*c*) to stop at hill number so-and-so"; and woe betide the man who goes beyond the stopping-point! It was found they were driven to that because the enthusiasm of the French and the British soldier carried him beyond the objective and the German counter-attacks always drove him to a frightful slaughter; so a limitation is put on him. It is very hard to restrain him because he sees what appears to be a field unoccupied which too often proves a trap, and so they set out to reach these objectives, but the first order is to kill the Germans.

After this raid of October 13, in which the British had lost quite a number of men killed thru their own barrage fire, the General said to me, "I would like to know how this happened." And so we went out to see. On our way out we passed a brigadier-general who was living under ground. He had some corrugated rooms he said resisted shrapnel, and he had a bedroom and a dining-room. Because the cannon had smashed all his window glass he had substituted bottoms of beer bottles set in cement, which gave him light and resisted shock. They had a latrine constructed in general American fashion, surrounded with canvas to give privacy, but he was informed that it would arrest the attention of an aeroplane and he would be bombarded, and that it would have to come down, so down it came, and the men went out to the latrine unprotected against immodesty.

We went on and moved along about two miles of trenches on the "duck boards" and examined where all the fighting had taken place, and the General asked a sergeant about the loss in this barrage. He said, "The time was a minute and thirty seconds, but the men got so enthusiastic after a minute that they ran into our own fire. The time ought to be shortened to one minute." After that the time was shortened. I just allude to that to show you that a major-general is perfectly willing to talk with and get instruction from a private soldier in his own ranks. This General came from one of the most illustrious families in England, but he was willing to get their viewpoint, and he tried to graft that in his military experience. He said, "Sergeant, how many did you kill yesterday?" And the sergeant replied, "Fifteen, sir." That excited my interest. He said, "Sir, I came to a dugout and I heard voices and I yelled 'Surrender!' and the boche said, 'Go to hell!' and I threw three bombs down." He said that with less excitement than I am telling you here. The General said, "That's pretty good; I will send for you in a few days." It does not take a Congress, twenty years after you are dead, to give you a medal of honor. A British army commander has a perfect right to confer a distinguished service medal on any member in his army; he has the right to give a war medal to any man. I saw a parade in which twenty men were decorated for events which had happened within thirty days. You could see the tension in every man in that brigade as they saw their men, their own associates, called out to be honored in the name of King George by the presentation of these medals that would go down to their children as a distinguished honor for bravery in the war. We have got to come to it; we have got to get rid of our American prejudice of rewarding men who do faithful things. The little piece of bronze is nothing for the risk he runs, but it is the stamp of his country's approval, and that is the greatest thing his country can do for him. To have Congress pass an act after you are dead and buried does not meet the bill. It must be done on the spot, and those men are encouraged to deeds of valor by seeing other men promptly rewarded for what they have done.

But I am getting away from the subject of engineering. I have been accustomed to dealing with engineers, and I suppose there are some here who, having large contracts in mind, do not look to the salvage at all. But the British engineer made up his mind that nothing should be lost, and the engineers' dumps, to which were brought back all wastage, twisted rail, wire entanglements, wheels that had been lost, were organized and they started in working them up, straightening the rails and sending them out again, and classifying everything, so if somebody at the front telephoned in they had need for a railroad they had a mile of rails to send him at once. They take the spokes of wheels and make duck boards out of them, and in the year that ended July 1, 1917, it is estimated that they had saved $25,000,000 to Great Britain in just the salvage these Royal Engineers were able to make. It is a new development in engineering science which is taking the economic laws into consideration and converting everything that has been used into something that can be used over again, and it is wonderfully developing the intelligence of the men. One dump visited had 500 men under a sergeant major, and I said to the commanding officer of the Royal Engineers of that army corps, "Is it possible that you can put that man in charge of all these men?" He said, "Yes, sir; such is the discipline to which we have brought the British Army that I could, if I wanted to, put a corporal in command of 500 men and not a man would think of disobeying or of not carrying out what he was told to do." That is the perfection—the *ne plus ultra* of discipline. The sergeant major is scrupulously dressed and he alone wears brass buttons. Britons use bone buttons to save the money that bronze costs, and we will come to it, too. They can remodel anything. If somebody finds he cannot use his machine gun, they telephone back to this dump and immediately a base is made out of old waste material. They do not take new boards and make them up into little things. Here if a man wanted a board two feet long he would not take the trouble to hunt it; he would take a sixteen-foot one and saw two feet off. It is not so there; they have come to the point of saving everything. And this leads me to a little other digression, having spoken about these brass buttons. In talking to the men of our 110th Regiment one Sunday night I dwelt considerably upon the snappiness of the British soldier; that no matter where I saw him, whether I saw him coming out of the trench in front or anywhere else, he was always spick and span and clean, and if we wanted to be successful in this war we would have to imitate that discipline. The British officer following me said it was not always so; the British soldier went into France a very dirty soldier, but when the order came down that every man had to be clean all the time the men all muttered, "What bloomin' idiot got off that idea?" He said, "After we had the mud chiselled off our boots and we were washed and clean we realized what it meant to be the only clean things in that section of the country, and we have been clean ever since, and have been a model to everybody else." It was a growth of this war, and we must grow to the same point—absolute cleanliness, absolute perfection of sanitation.

Among the places I visited on the front was Verdun. The loss on both sides was appalling, and, while that fight shook the strength of Germany to the limit, the men that France lost cannot be replaced. That country for miles around is pock-marked with shell holes. A fort which was considered a masterpiece of modern military engineering, built of reinforced concrete, extending many feet under ground, was pommelled into atoms by the German artillery, and the plucky French soldiers, while the pieces were coming down over their heads, dug down and built a new fort of rock and granite that in the end held that battle line and won that fight for France. In this fort you might think you were in an anthracite coal mine. It has artificial ventilation. I was in a hospital there with a better odor than many hospitals built on the surface of the ground —perfectly pure, in which no ray of sunshine ever entered. After we had wandered all thru it—and up to that time I was the only American general officer that had gone down there—the commander said he would like to take me up and show me the top. We climbed up and got out on top. It was pouring rain. I remember it because it was my sixty-second birthday. He said, "If the sun were shining, you and I would not live five minutes here, but I guess you are perfectly safe." He said, "You can wander around in that direction and not go down again." Afterward I said, "Major, why did you have those two orderlies follow us out?" "Well," he said, "to carry back the fellow that might be hit." I saw two shell holes side by side that were as big as this room. I am not exaggerating. That is the kind of shell hole that is put thru that old concrete fort under which this new fort was being built, and the courage and the resolution of the men that did that work and the engineers who designed it and constructed it is, to my mind, phenomenal. No wonder the French called their engineers "Genie," thinking of the "Arabian Nights" and the genie that came out of the vase and accomplished all those wonders. They are the perfection of mathematicians. They have figured out the influence of the earth on a shell travelling out of the cannon; how much farther it will shoot north than south; how much the height of the moon deflects the shot, and what is called the ultimate error of the cannon shot is disappearing under their mathematics. If a commander cannot point a cannon within ten feet of the shot he is not counted a success. That is an engineering triumph and mathematical triumph of the highest degree.

Somebody asked me to-night how they located the shots, and whether by aeroplanes. I said, "Not alone. There are three ways of doing it—spot flashing, sound ranging, and then the aeroplane to check both up." The most uncanny thing is sound ranging; it is shooting around the corner, surely. They have a very delicately devised wire that is heated red hot, and so sensitive that if you blow your breath on it it goes out. They put up six or eight of these wires at different points, all connected by electricity back to the central station, and then have a moving-picture machine. When the gun goes off a button is pushed and the moving-picture machine goes into action, and as the vibration of that gun reaches each one of these stations there is a little quiver in the line that is printed on that film, and when it comes out it is handed over to the officer, and he goes to a carefully calculated table and proceeds to locate that gun by the vibrations taken miles away from where the recording instrument was, transmitted underground by wires buried six feet and brought back to this little encasement of his and printed; and those little strips of paper come back and locate the gun that fired that shot. Then he proves it by spot flashing, and as the sound travels from one place to another a number of people push a button, and, knowing that sound travels so many meters a minute, they prepare a map on which to locate it. Because paper expands and contracts, they make the map of zinc and they cut the paper in two-inch squares, so that nothing in accuracy shall be lost by the expansion or contraction of the paper under heat and dampness. They have a parabola around it with everything calculated, and stretch six strings around that, and when the six strings get over the same spot there is the gun, and when the other six strings get over there they are sure it is there, and then they get the airman to fly over it, and he can see if they are right, and it is nine out of ten if they drop a shot over there that that gun goes out of business. That is engineering gain. That is progress beyond the point where men set up a right-angled corner to set up a stone wall to put up a cheap house.

You and I have been taught to believe that the French are the most mercurial people on earth. I visited a Frenchman in his fortification home and the map showed it as a "cabaret dugout." I said, "General, why do you call it that?" "Well," he said, "because nobody here sings or dances." And while he was working in that little room a ship's clock struck six bells, and I straightened up and I said, "That is a singular sound here." He said, "That's a touch of home; I am thinking of my wife." He had brought from his home that little ship's clock that would carry him back to Bordeaux, and once every hour for a moment his heart went back home and the other fifty-nine minutes it was pounding shells into the boche.

I have visited all the training schools—or a training school in every army over there. I have already said to you that I saw nothing equal to the engineering work that Colonel Snyder has done down at Augusta; but at one of the French schools I saw a thousand boys of eighteen out one morning at drill with ice on the ground, stripped to the belt, and not a thing on above their breeches, singing and working and drilling as if they were at a Sunday-school picnic on the Fourth of July. I tell you, when we can drill American boys up to that point—when they will go out when it is cold enough to freeze, with ice all around them, and go at their work without clothes on, then they will produce results.

They say that the French are anæmic and tubercular. There are not many of those now. Man for man, they are better than the German boys captured at the Chemin des Dames fight of the same age. They are healthy and muscular. No effort is made to make specialists. They go in for all-round development. They have learned that specialists have prolonged this war and they are doing away with them. An instructor is detailed to every thirty-two to forty-eight men who takes them from the setting-up exercises to the latest type of machine gun. When a boy has left that school he has covered the whole course of instruction; he is not a specialist, but a universalist in everything that pertains to military art. That is one of the lessons that three years of warfare have taught them. It is the man who studies it all that is able to do it all, and he does it all. I saw a man fire eleven shells from a Stokes mortar and had them all in the air at one time before one struck the ground, and not only that, but his assistant trained the gun so accurately that they almost struck in a mathematical line. To do that you have to move your fingers pretty fast to get them out of the road. The shell that goes into a Stokes mortar has a little ordinary shot-gun cartridge at the bottom of it, and when that drops into the mortar it hits a pin that sets off the little percussion cap, and that little cap fires the shot out of the gun and then it commences to unwind the paper fuse that goes out, and when that is unwound the business begins, and if it unwinds too fast they have a funeral for the fellow that fires it.

The British engineers have perfected barrage work. I wish I could show you a diagram that is issued to an artillery commander from the chief engineer's office telling him how to put down his barrage in a certain fight, and then he calculates it out according to all this modern figuring with regard to artillery range in a way that produces results. They were successful in their last two raids because they had invented a new species of barrage fire which I am not permitted to say anything about, except to say that it is the highest kind of engineering art, and it rendered the whole front absolutely untenable to the Germans. When the British reached their objective there was not a living boche nor any to upset their reversing these entrenchments. What is known as consolidation was equally accomplished by the result of the mathematical accuracy of this new system of barrage work. You all know, of course, that a barrage is a line of shell fire timed to fall in a reasonably straight line. There is a variation, perhaps, of 75 to 100 yards in the width of that, and that is made intensive or light, in accordance as the men move forward or backward. They have a system of signalling which is more or less elaborate, the meaning of which has to be changed every day to get rid of the spies; and they have now added to that the intensity of machine-gun fire in the much-despised Lewis gun, which in every army but ours is considered perfection as a military piece. Our misfortune was that when they used them on the Texas border they furnished us with condemned ammunition and that did not work. They use them over there with good results, and they have effectively added to the results.

When I was on the American front I went out and visited the American training school that Colonel Upton had put in without sufficient help; he was absolutely working with his own hands, with pick and shovel, to get the thing done, and yet producing results far beyond any work I saw of anyone. Give the American an opportunity and he " comes across " with whatever has to be done. He takes the three years' experience of his brother and pushes it ahead beyond anything he has had, and these schools are the wonder of the Allied forces. The intensity of interest with which those men of ours—officers and enlisted men side by side—take up and carry on the instruction given them is simply wonderful to the French and English officers. The accuracy of their rifle fire is truly commendable. They are developing that spirit that must prevail all over in this war and in this country, that the men must be taught the whole object of the attack is to kill. He must be systematically taught that when he sticks his bayonet in the sack of sand he must growl like a dog. He does it. I have seen men run 250 yards and stab four successive rows of dummies, jump down in a trench six feet deep and with their rifles put eight out of ten shots in the bull's eye. One would think that they would be completely winded. The men who did this shooting had a little bit of a target, because the range was not great. They gather those all up and count the hits, and the fellow that does not make fifty per cent. has to start and do the work all over.

Somebody asked me to-day whether engineering was dangerous; he was a reporter on one of the city papers. I said that the engineering work back of the salvage dump is not particularly dangerous, but if it is the engineer's duty to lay out a line of front trenches the minimum of loss is 150 per cent. In other words, if twenty men ordered to map out a trench go over the ground with white tape so that it can be seen at night, thirty of them will be killed before the twenty lay the work out. In credit to the engineer, be it said that there are two men to go over for every man that falls. The aeroplane only has them beaten 15 per cent.; 165 per cent. of them die. Aeroplane losses seem very small as they appear in the papers, but there are ten men on the ground for one in the air. Taking the loss of just those in the air; it is 165 per cent. of those that go up. This gives a little idea of the great seriousness of this fight.

If you were to walk the streets of Paris and see three out of five women in black, and almost every man wearing black on his arm and you mingle with those people, you would find no smiles, but a stern determination that there can be but one end to this conflict. Somebody asked, " Is it true that France is bled white? " I replied, " Yes, true in one way; they nearly froze last winter." In 1916 they had no fields cultivated. It became necessary to take men from the army and have them go home and plow. They had to make some provision to get coal. They have raised the allowance to 960 pounds of coal for every month for a family of four persons. You know what that means from the little experience we had last week. And that is all you can get, rich or poor. Yet they take it stoically. I took luncheon one day in Paris; it was a meatless day and I invited a lady—a relative of a friend of mine. We went to a little fish-house. I never take sugar in my coffee. She asked me for the sugar and she put it in her pocketbook. She said to me, " I suppose that is funny to you." I said, " Surprising—not funny." She said, " You know if sugar was to be bought I could buy it." I said, " Yes, I have no doubt about that." " But," she said, " I cannot buy any sugar, and so I am going to use yours." I said, " Now I know why the waiter, when he waits on me, dumps the sugar in his pocket." She said, "That is the biggest tip he gets." They meet this sacrifice with absolute cheerfulness; they stand up to it bravely.

I had a young French officer assigned to me. He was a schoolboy when the war broke out. He was a private. He is a captain now. He had not smiled in three years, he said. He had not seen his father in a year and a half, and I ran thru to Paris with him, just to let him see his father. He protested that it was not according to his order. When I started he said, "Where are we going?" I said, "You are going to see your father." I took him and he called to see his father and had dinner with him, and the next morning we went back and he said, "That is the first I have seen my father and mother in two years." And yet he had never been more than fifty miles away. He had seen all the men in Verdun lose their lives, but he had a perfect determination that he would not go back to his profession until this war was won.

I met a French captain who had three sons in the army. He was retired and he cried like a child because he would not be permitted to fight on. He had already lost two sons and two brothers, but that did not count; he wanted to go on "for the glory of France and the liberty of the world!" Those are the types of men we have to fight with. We have got to bring ourselves up to that standard. We must make the people of this country realize that the game is the biggest ever played, that the stake is life, liberty, and democracy—the biggest jack-pot that was ever opened—and we have to stay in until the other side throws down their cards and the victory is ours. There can be no doubt about the result if we in the United States loyally stand by the Government, swallowing all imperfections.

That there will be some imperfections is only natural. Let us do all we can to help send our soldiers across the water as fast as possible, trusting to luck that the provisions get over there to take care of them, realizing that the victory can come only thru man power and brain power; that the aeroplane, the hand grenade, and the bomb are auxiliaries and auxiliaries only. The French and the British have learned that the moment a man has to rely on a hand grenade, he relies entirely on that and he will not fight. They have to be taught and our men have to be taught that there has been no improvement in military tactics since old General Forrest, who used to say that the only sure way to win a battle was to "get there firstest with the mostest." It was bad grammar but sound doctrine. We have to get the most men there in the quickest time and have men with brains to win this war. Everything else is an auxiliary. The cost is terrific.

I have carefully avoided telling you anything of the wreckage I saw. I am only going to tell one little incident. While coming in from the battle of Chemin des Dames, at a little station on the road a doctor rushed out and waved to the car to stop and then hesitated because he saw a general in it, and I asked, "What do you want?" or rather I had somebody say it in French. He replied that he had an officer who had been badly wounded and he wanted to have him taken back to a hospital. The trip was about seven miles. We took the officer in the car, and as we did so he was about to faint. When he saw who was holding him he said, "This won't do; a first lieutenant cannot be held by a General." I said, "Don't worry about that. Tell us how it happened." He said, "Well, we went up over the top, and there was just one roll on the machine gun and the captain was dead." He began crying. He said, "I am not crying for myself, but for the captain; he left a wife and three children." He continued, "This is the fourth time I have been wounded. I will be back in the spring." But I could read the tag and I knew he will not be back, because he will have to sacrifice one arm.

Incidentally we went thru and looked at the wreckage. The fight had not been over more than two hours and there were over a thousand men back at that hospital several miles from the front, under the care of surgeons. Many of them were Americans. Word went forth that an American general was going thru, and one doctor from America came back to speak to me. He said, "I am operating on an abdominal case. I must talk to you. I want you to carry the message back over to America that we are not getting operating garments enough. We have used fifty-four to-day and it is only noon, and from now on we will have to use bloody ones," and, he said, "You know all the dangers from that." I say the message is that the Red Cross cannot work too hard and too zealously. Make up your minds that your American boys over there are going to be well looked after. There is absolutely no excuse for venereal troubles; that is all bosh; a carefully handled division will not have it. It is the commanding officer's duty to see that his men are healthy, and that is being met splendidly across the water. Trust your boy there, if you have one; if not, tell your neighbor to trust his boy over there. He can be made safe against venereal disease. He cannot be made safe against bullets; that is a risk of the gun. Pneumonia and the bullet are the only two things you need to fear. Pneumonia in that country, I am afraid, is not a preventable disease. It can be reduced very much if we properly equip and protect our men; but we must get them there, my friends, and with a consciousness of the engineering art and science as evidenced by the military engineers of the French and British armies they will pave the way to ultimate success. Anyone who has studied the fight of Passchendaele Ridge and saw those Australians deliberately climb to that summit in order that they might sleep somewhere where the mud was not deep enough to bury them realized the courage back of that movement. Anyone could admire the French general who carried them to victory at Chemin des Dames when he said to the army commander, "This fight cannot come off on the 22d of

(Continued on Page 68)

THE HISTORICAL LIGHTING OF INDEPENDENCE SQUARE, PHILADELPHIA*

BY E. F. KINGSBURY

INTRODUCTION

If the complete history of Independence Square were known it would undoubtedly be found that there have been many proposals to change or restore the lighting and other features of the place to give it a more historical air. In only one such effort of some three or four years ago are we interested, when the City of Philadelphia, in coöperation with the Philadelphia Chapter of the American Institute of Architects, undertook the partial restoration of the Square; partial because its complete restoration is impracticable. For example, in about 1800 and just prior, there was a brick wall, 8 to 10 feet high, with a huge, unsightly gate on Walnut Street, in the center of the block. Previous to this there was an old wooden fence and the grounds were unkept. When the Declaration of Independence was read to the assembled crowd on the 8th of July, 1776, there was an unsightly wooden platform near the center of the Square that had been erected in 1768–69, on the proposal of the American Philosophical Society, upon which a telescope had been mounted to observe a transit of Venus. The purpose of the restoration was rather to make such changes as would tend to restore and maintain the historical appearance.

Various lighting schemes were proposed at first, but after much discussion two things were decided upon: one that the illuminant should be gas, and, secondly, that the type of post and head used in Philadelphia the last quarter of the eighteenth century should be adopted. Three factors decided in favor of gas. Under the lease agreement existing between the gas company and the city, the latter could maintain the lights very cheaply. Also, the cost of new piping would be less than conduits. It was agreed by all concerned that the same illuminating effects could be obtained with gas as with electricity, so there was no choice in this respect.

To determine the type of post and head in use around and just prior to 1800 proved to be rather difficult, at least in detail. There is no detailed description of the lighting in Philadelphia at that time known to exist. Birch's Views of Philadelphia, published in 1800, show many posts and lamps, but, while there is a general similarity, the details differ. It is hard to proportion a head from them. Several different styles of posts are shown; one is a straight wooden post, apparently nothing but an extended curb post tapering slightly toward the top. Another is the ordinary curb post with a smaller pole set in the top, giving an appearance much like the post finally installed in the Square. These have goosenecks at the tops. A few lamps are supported directly at the base without the gooseneck. This is especially true of those on the top of the watch-houses, one of which is shown in front of the State House. Cast-iron posts did not come into use until a later date, probably when gas became generally used for street lighting. It should be remembered that the pictures are all according to some artist's fancy, and hence it is not surprising that the lamps should vary in proportions, as they were of minor importance to him in the landscape. One thing is fairly certain: a common type of lamp was in use thruout the city at the time. An old lamp head was found that helped considerably to give the exact dimensions. Fig. 1 shows the type of lamp and post finally installed in the Square. It is characterized by its extreme simplicity, contrasting strongly with the more ornate units frequently used to-day. Fig. 2 shows a lamp suspended by a bracket from the corner of one of the State House wings. Fig. 3 shows a suspended unit in one of the arcades connecting the two, while Fig. 4 is a general view along the west side of the Square to show a row.

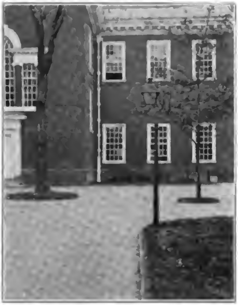

FIG. 1.—INDIVIDUAL LAMP AND POST.

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* Presented before the Illuminating Engineering Society November 16, 1917, at the Engineers' Club.

HISTORICAL

It has been well said, "For every one that doeth evil hateth the light, neither cometh to the light, lest his deeds should be discovered."[1] Such indeed is the motive of early street lighting. In the Laws of Pennsylvania, 1700–1775, page 414, we find in a law passed March 9, 1771, for regulating and continuing the nightly watch, enlightening the streets, lanes, and alleys of the City of Philadelphia, the following preamble: "Whereas the well ordering and regulating the Watch and enlightening the Streets, Lanes, and Alleys in the Night Time, within the City of Philadelphia, have been found on Experience, very necessary to prevent Fires, Murders, Burglaries, Robberies, Breaches of the Peace, and other Outrages and Disorders; therefore be it enacted, etc." In this act wardens were appointed with broad powers to have charge of the watchmen and street lamps. The street lamp of early Philadelphia, the prototype of those standing to-day in Independence Square, faint and flickering tho it was, demands much credit. A beacon to guide the traveler safely along his way, it loosened the bolt which twilight fastened for the night. It calmed the fears of the family huddled within, lest some wandering band of incendiaries should set fire to the house. It encouraged that social and intellectual intercourse of the evening hours so essential to our modern welfare.

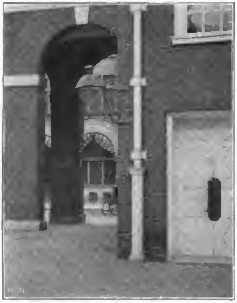

FIG. 2.—INDIVIDUAL BRACKET LAMP ON CORNER OF WING TO STATE HOUSE.

It is important to note that the type of head first used in Philadelphia was round, and, locally, the square head is an outgrowth of it. These were, for a while, private lamps maintained by property owners. We read in Watson's Annals of Philadelphia, vol. 1, page 102, a statement of a Robert Venable, an old colored resident of Philadelphia, that "the first lamp he ever saw in the street was round and was set up before Clifton's door—a large two-story brick house of double front, at the southeast corner of Clifton's Alley (since called Drinker's) and Second Street, below Race." On page 212 we learn that in 1751 an act was passed for a nightly watch and for enlightening the city. The full title was, "An act for the better regulating of the nightly watch within the city of Philadelphia, and for enlightening the Streets, Lanes, and Alleys of the said city, and for raising of money on the inhabitants of the said city, and for defraying the necessary expenses thereof." On the 3d of October, 1751, the *Pennsylvania Gazette* announced that on Monday last the streets began to be illuminated with lamps according to the act. In the same issue we read, "Last week a person was convicted of breaking one of the public lamps by throwing an apple at it and paid a fine of 40 shillings." In the act of 1771, already referred to, a penalty of 25 pounds was provided for wilfully injuring the lamps.

Oberholtzer's History of Philadelphia, vol. 1, page 185, says that the first street lamps used whale oil and had round globes. They were sometimes hung out from buildings or on poles in the street or on the pumps. On page 230 he says that in 1767 there were 320 public lamps. At this time the population of Philadelphia was about 26,000.

Prior to the establishment of public lamps there were undoubtedly quite a number of private street lamps, inasmuch as contributions were made toward hiring a man to light and maintain them. Scharf and Westcott, in their History of Philadelphia, vol. 3, page 874, say, concerning the private lamps, "A few street lamps were then put up, owned by private citizens, who, finding it troublesome to attend to them, met in consultation and agreed to pay a man a certain monthly sum (each three shillings and nine pence, says

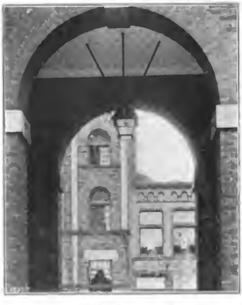

FIG. 3.—UNIT SUSPENDED IN AN ARCADE TO THE STATE HOUSE.

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[1] John iii: 20.

John Smith in his manuscript journal) to light them nightly."

In the *Gazette* for May 30, 1751, there is an advertisement of some merchandise by a John Clifton "at the Two Lamps in Second Street between Arch and Race Street," showing that anyone having two lamps furnished a distinguishing mark. This is undoubtedly the John Clifton that Benjamin Franklin says, in his autobiography, was the first person to impress upon the people the utility of street lighting by placing one at his door. Franklin also says the original globe lamps were first supplied from London. The writer has been unable to find a picture of the street lamps used in London at this time, which were undoubtedly copied closely by those imported.

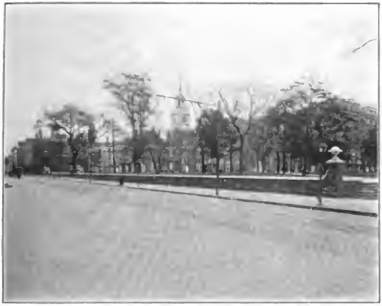


FIG. 4—VIEW OF WEST SIDE OF SQUARE SHOWING A ROW OF GAS LAMPS.

Franklin says in his autobiography that at the time of his going to England in 1757 an act was passed for paving and enlightening the streets. This the writer has been unable to verify. From what has been said above, it cannot mean the date of the original installation, as 1751 seems to be confirmed beyond a doubt. A supplement to the original Watch and Lighting Act was passed early in 1757, but it did not concern the lighting. There is a reference at this point in the autobiography to "See Votes," meaning the "Votes of the Assembly" of the Province of Pennsylvania. We would call them now the official proceedings. A search of these records around that date failed to confirm his statement, as did a search of the "Laws of Pennsylvania," 1700–1775. The mistake is perhaps not surprising, tho, when we take into consideration the reminiscent nature of the autobiography in question and the difficulty under which was written the latter portion wherein the statement occurs.

As is well known, Franklin made two improvements in the original globe lamps. One was replacing the original round head by four flat panes to lessen the expense of breakage, and the second, the placing of a long funnel above the lamp to draw up the smoke, crevices being placed at the base to facilitate the admission of air. The whale-oil lamps then in use were extremely smoky, and the added ventilation greatly improved the cleanliness and utility of the lamp. The time of the change from the round to the square head is not known. The type of head finally installed in the Square is undoubtedly that designed by Franklin himself.

Lamps with square or hexagonal heads were very common in early street lighting abroad, being developed from the early lanterns, which were usually square or rectangular, and they underwent an evolution which it is doubtful was influenced by our local trend. The earliest lamps were either mounted against a wall or were supported out on brackets from it. While the shape of the head may not be original with Franklin, this, together with his added suggestions concerning ventilation, made a distinct advance in the improvement of the early oil street lamp.

Enough has probably been said to give the lighting of Independence Square its proper setting in the local history of public illumination. No attempt has been made to develop the history of the subject in a systematic manner. That is far beyond the scope of the present paper. From the torch carrier to the mantle and the filament seems, in its scope, like a completed evolution. History is but repeating itself. We are

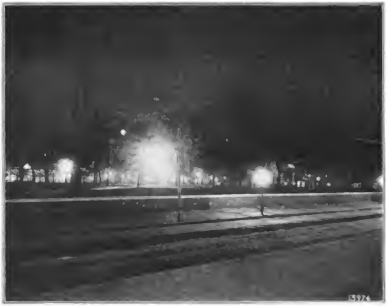


FIG. 5—NIGHT VIEW OF THE SQUARE.

in the porte-flambeau period of modern street lighting: that period when most of our vehicles carry their own powerful lights. Can we not expect that we will have eventually such good and universal lighting of our city and country streets that such good and universal lights need only be bright enough to be safety markers?

Description of the Installation.

There are sixty-two lamps in all—thirty-six in the Square and twenty-six on the adjoining streets. The lamps average about 75 feet (23 metres), center to center. The lighting is designed to give a uniform, moderately high illumination in most parts of the Square and a somewhat higher illumination at the street corners, in the middle of the Square, and in the plaza near the tower. The units had to be arranged so as to interfere as little as possible with trees and tree roots and at the same time to be symmetrical. Two are hung in the arcades to the State House and four bracket lamps are on the southerly corners of the wings. Entirely new gas piping was laid thruout the Square. Fig. 5 is a night view of the Square.

The lamps as installed seem rather glaring, and from that standpoint the use of some opal would be justified. On the other hand, they would not look so simple and historical, especially during the daytime, when opalware would be very conspicuous. A distribution curve of a unit is given in Fig. 6.

The illumination on a horizontal plane 3 feet high varies from a maximum of 2 to 3 foot-candles directly beneath the units to a minimum of 0.02 to 0.05 in the darkest spots. The Square is heavily shaded, and it was difficult to avoid the dense foliage in placing the lamps. There is, however, plenty of light for adequate policing, which is of primary importance.

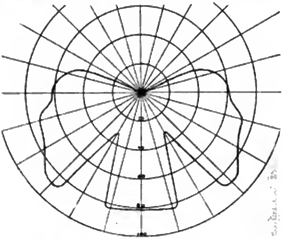


FIG. 6—DISTRIBUTION CURVE OF A UNIT.

CONCLUSION

The historical lighting of Independence Square is of especial interest because of its association with the name of Franklin. Our information is all too meagre. A few passing remarks written by himself at the close of a busy life is all we know. The lighting stands a simple, yet fitting, memorial to that illustrious name and to the historic period of the Revolution.

(Illustrations courtesy of the Illuminating Engineering Society)

UNITED STATES ENGINEER TROOPS IN FRANCE

(Continued from Page 64)

October; there is still danger ahead of destroying our men; we must have another day"; that showed the care that the general was taking of his enlisted men.

May I say that the best meal I ate in France was cooked forty feet under ground, in the home of this general, living there, figuring on what was to come to France after the war was over, considering all the social dangers thru which they would have to go, and accumulating a fund from his rich friends in France, that each man that went back might have a handsome sum of money to help him and his family; he mapped out a fight that was absolutely successful. Before every fight the whole plan is carefully gone over with some representative of the Government in Paris, and every chance is carefully considered, and they are fighting with a determination and a persistence at the end of three years just as great as it was in 1914, when Joffre and Foch pushed their men out in automobiles and stemmed the German tide by flesh and blood, against all the machinery of the German Empire. I think if we could only look ahead and see into the future we would resolve ourselves with new energy to the task that is before us. There can come no peace until the Stars and Stripes are on the east bank of the River Rhine.

OFFENSIVE AGAINST THE SUBMARINE*

By JOSEPH A. STEINMETZ, A.S.M.E., S.A.E.
PRESIDENT AERO CLUB OF PENNA.
MEMBER SUBMARINE DEFENCE ASSOCIATION

THE shipping world is threatened with extinction by this greatest of danger, the enemy submarine, which even to-night may be lurking beneath the wintry seas just outside our ports, ready to strike our ships their death-blow.

JOSEPH A. STEINMETZ

Millions of tons have gone down and thousands of lives have been lost and the havoc continues.

The departments of government, the national engineers and workers, and the unhappy inventors are grappling with this dread problem, grimly and resolutely, and the menace will be squarely met.

If we do not get the enemy submarines, they will get us! There is not a moment to debate nor a minute to waste! Thousands of lives and billions of treasure are at stake. To date more than 800 craft have been torpedoed.

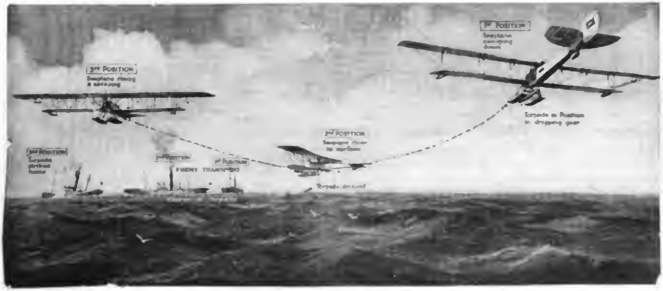
Great improvement in reduction of sinkings has been recorded since last April, when a total of 55 ships were sent to the bottom in one week.

In May, when our destroyers went in, and during the summer the sinkings dwindled, and with the improved armament and speed of the commerce ships conditions are bettering. The British Prime Minister, Lloyd-George, announced recently that the Allied Defense had sunk five enemy submarines in one day, so we feel confident the issue will finally be met.

In an Associated Press Despatch from Washington, dated November 13, the Honorable Secretary of the Navy is quoted as stating "that important progress has been made in the problem of locating submarines," after which we are encouraged to note "that their destruction is a comparatively simple matter."

In discussing the tremendous response by the creative zeal of the nation's inventors, the Secretary mentioned that 40,000 separate suggestions, plans, or models of offense and defense devices had been submitted to the Naval Consulting Board since the United States entered the war against Germany.

"The idea that the submarine will be overcome by a miraculous invention is not now seriously considered," the Secretary said. "The more intimate knowledge the civilian obtains on this subject, the more convinced he is



SEAPLANES LAUNCHING FREE TORPEDOES AGAINST ENEMY SHIPS—(ADMIRAL FISKE'S PATENT.)

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* Address presented at Joint Meeting of American Society of Mechanical Engineers and Franklin Institute, December 11, 1917.

that the submarines can be conquered by persistently hunting him down by the weapon of which he is most afraid. This is the armed service boat, equipped with all the latest scientific devices and typified in the modern torpedo-boat destroyer. Foreign naval authorities have frankly stated their admiration of the degree of perfection of American designs.

"In regard to the protection of ships against torpedo attack, the undeniable evidence of recent months of submarine activity has demonstrated that the immunity of a vessel depends very largely on its speed and maneuvering ability. There is a possibility that some artificial means of protecting cargo-carrying vessels may be found practicable. In no other field have so many suggestions or so many duplicate inventions been presented to the Board."

LAUNCHING TORPEDO BROADSIDE FROM DECK FIRING TUBE OF DESTROYER AT 30-MILE SPEED.

The Secretary said that the thought on submarine defense may be subdivided in three groups:

1. Any methods to accomplish the destruction of submarines, involving their detection and destruction after detection.

2. Means of avoiding submarine attack, involving instructions for merchant vessels, proper handling of vessels, camouflage, smoke screens, and other confidential information known to American naval authorities.

3. Protection of ships against torpedo hits.

All of the 40,000 suggestions submitted have received careful consideration, and much valuable aid has been given to various branches of the war service. Many proposals, however, have been found to be impractical, largely due to the failure of inventors properly to inform themselves of certain fundamental principles.

Many inventions of real merit have also been submitted. The departments will receive suggestions, but the engineers will find some difficulty in having practical development work done at government expense. The sea is free beyond the three-mile limit, and anyone may develop at his private expense devices related to the national defense. The various Boards will hold as confidential such helpful disclosures, but it seems there is no general authority to reward by purchase or royalty unless a patent is obtained, when the inventor acquires a negotiable asset.

Unfortunately the publicity of patent issue detracts from the strategic value of the device. It is hoped that in time such patents will be ordered withheld from issue, to prevent publicity when an obligation to purchase will be automatically created by that department recognizing the need of the patent.

To skin a rabbit we must first catch him, and likewise to destroy a submarine we must first find him.

Therefore the method of catching, as mentioned, is in its proper order of importance. The sorry part of it all is that the submarine having the greater advantage of lower visibility, approximating invisibility, refuses to be located, and gets home a surprise torpedo, and the program of sinkings continues.

Ninety per cent. of the damage and loss comes from that first torpedo, and the necessity of forehand knowledge of the submarine's location, in relation to the approaching ship, bears an equal percentage of importance to the equation.

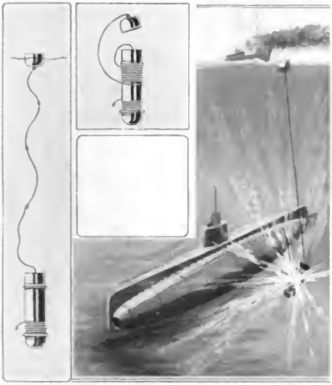
In certain conditions of sea and weather it is practically impossible, by visual observation, to detect the enemy periscope.

Various listening devices are being developed, with most encouraging results, and the public press hints at the wonders of inventions as yet untried, those stirring dreams of the arm-chair strategist.

To locate the enemy submarine and side-step him does not solve the problem of his extinction by destruction, and the Secretary is right in recognizing a solution of the menace by direct gunfire attack.

The more guns we mount on our commerce ships, the greater the increase of our swift destroyer class, the more certainly have we met the submarine. We must blow him out of the water and hunt him from base to base by direct gunfire attack.

Of late there has been perfected a means of deep-water attack against submerged submarines by the use of the selective depth bomb. This device, variously charged with from 50 to 500 pounds of TNT or other high explosive, is so arranged that it will detonate at a predetermined depth, estimated to reach the level of the submarine that is lurking below the surface. These depth charges are launched from fast surface craft whose speed carries them away from the eruptive danger following the explosion. The under-water shock is sufficient to break in the hull plating of a submarine in any direction equal to about three times the vertical depth at which the charge explodes.



DEPTH MINE SHOWING SELECTIVE TYPE OF FLOAT PULL

A well-known type of this depth bomb provides a hollow float, connected to a thin cable or cord that is wound around the outside of the explosive container, the selective depth being determined by the length of the unwinding cord that pulls the detonator when the mine reaches its selected depth.

[Reference:—U. S. Patent Application 161,874.]

Reference is here suggested to the topographical map and contour of the bed of the North Sea, which, contrary to popular supposition, is a comparatively shallow body of water, except for three guts or submarine lanes and the greater deep channel along the Norwegian coast.

The Dogger Bank Ridge is but 50 feet deep and the average bottom of the North Sea lanes about 200 to 300 feet, while the deep strip, or main lane on Norway's edge, is some 900 feet deep.

An attack by barrage continuous discharge of depth mines from numerous patrols covering each known submarine lane would check the freedom of these passages with justifiable chance of destroying the enemy U-boats.

The Naval Consulting Board, known so favorably to us all, has worked indefatigably in the consideration of the vast number of suggestions that have been offered.

As a guide to help solve this submarine menace the Board has recently issued its Bulletin No. 1 (July 14. 1917), relating to the "Problems of the Submarine." Copies will be furnished free by addressing the Navy Department.

As this information is official and helpful to a clear understanding of the submarine warfare, offensive and defensive, it would be proper to quote quite fully from this Bulletin.

PROTECTION AGAINST SUBMARINE ATTACK

This subject, which is occupying the public mind as is no other, divides itself into a number of problems, the most important being the following:

(a) *Means of discovering* the approach of a hostile submarine and locating it so as to permit of prompt action for combating its attack.

(b) *Protection of cargo-carrying ships* by nets, guards and screens.

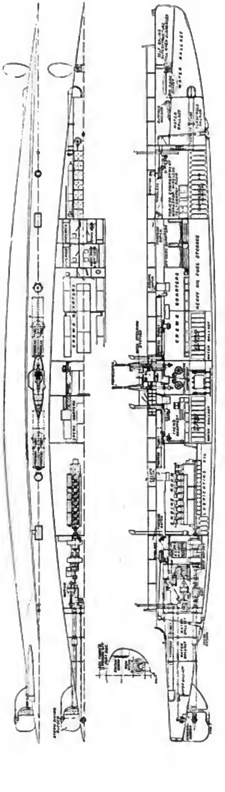
(c) *Protection thru decreasing the visibility of vessels.*

(d) *Methods of destroying or blinding* a hostile submarine.

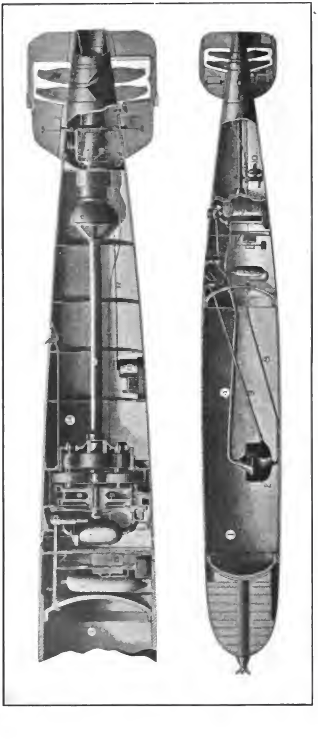
(*e*) Mines, their use and control.

(*f*) Torpedoes, use and counter defense.

Submarines, to operate most effectively, must approach within close range of the vessel which is intended to be torpedoed. The installation of offensive weapons on



VERTICAL SECTION OF SUBMARINE.



TORPEDO DETAILS—SHOWING "WAR HEAD," COMPRESSED AIR RESERVOIR, MOTOR AND TRANSMISSION TO PROPELLERS.

the merchant marine has increased the necessity for the utmost care being exercised by the submarine commander in remaining unseen by the officers on the vessel to be attacked.

Reports from abroad indicate that in many cases submarines must have remained along certain lanes of travel for periods extending into weeks of waiting with the expectation of torpedoing certain vessels. Under certain favorable conditions, where the waters are less than 200 feet in depth, the safe limit of descent, a submarine might lie at rest on the bottom, and if equipped with sensitive listening devices attempt to detect the approach of a vessel. As soon as this evidence was secured the submarine might come to the surface for a quick observation by means of the periscope and in this manner obtain the proper aim which would be required to register an effective hit.

In case the water is more than 200 feet in depth a submarine must be kept in motion to obtain steerage way in order to hold its proper depth of submergence. This speed may not exceed four or five miles per hour, but to remain submerged, and at the same time unobserved, the water must be at least 60 feet deep.

The latest type of submarine which is being used abroad has a surface speed of at least 17 knots per hour and a submerged speed of probably less than 10 knots. The superior gunfire from the merchantman which has been properly equipped would make it necessary for the submarine commander to obtain his observations, such as would permit accurate aiming of the torpedo, during the very brief interval of time required to come to the surface for observation thru the periscope and to again submerge.

If running near the surface, the periscope might be raised, a quick observation taken, and lowered again within 30 seconds. If, however, the submarine is on the surface and hatches uncovered, from one to four minutes will be required to completely submerge, depending upon circumstances.

A submarine of recent type probably has a total radius of action of as much as 8000 miles when traveling at a moderate cruising speed of from 10 to 11 knots, and may remain away from its home-base for as much as one month, without requiring either fuel or other supplies during this period.

The "U-53" on her espionage visit to Newport Naval Station and her subsequent torpedoing of a half dozen friendly and neutral ships within sight of our shore is a concrete reference of what can be done as to radius of action and which may be again attempted in greater force.

A recent estimate of an Allied naval officer determines that the enemy submarines are at surface over 95 per cent. of their time when cruising, thus giving opportunity of accidental sinking by night ramming by surface craft as well as for direct surprise attack during fog intervals.

The fact of submarines being so little time submerged has developed a simple yet efficient strategy to determine their location. The Allies have used their submarines as feed lures for seagulls, which hover over the hull tempted by their food, and follow untiringly in the wake of the submerged craft.

The gulls, not recognizing friend or foe, follow the German submarines patiently, expecting to be fed and quite innocently declare the location of the enemy underwater boats to the Allied patrols.

This type of submarine may have as many as three periscopes, two conning-towers, and two rapid-fire guns attached to the upper portion of its hull.

The vessel is steered by very efficient gyroscopic compasses, which are unaffected by extraneous magnetic or electrical influences.

A general understanding of the capabilities of the modern submarine for offensive operations will make it easier to appreciate the importance of the three problems which follow:

(*a*) MEANS FOR DISCOVERY

The *aeroplane.* When the condition of sea and air are favorable, a submarine is readily discernible from an aeroplane flying at a sufficient height, even tho the submarine be submerged to a considerable depth.

While aeroplanes have thus been used successfully in the English Channel, they are unable to fly far out to sea where the submarines are now most active. Mother ships for carrying and launching aeroplanes might be used in this connection, but there are only a small number of such ships in operation and the construction of others under present conditions is necessarily a slow process.

The airplane promises to play a very serious and important part in sea warfare and torpedo service.

Admiral Fiske, U. S. N., retired, invented, some years ago, a torpedo-plane which in effect is a seaplane carrying on its keel parallel a marine torpedo.

The torpedo-plane skims close to the surface and delivers its attack directly in line with the enemy ship and releases the torpedo which speeds to its target.

The Germans are reported to have used this device successfully in sinking Allied surface craft in the North Sea.

Private initiative and subscribed money is now supposed to be developing this method into a practical device for use of the national defense.

A similar weapon is described in United States Patent 1,223,212, covering an aero-marine-torpedo which provides for a tubular-shaped charge towed by an airplane, which, rising in flight, drags a wire towline across the victim ship and, speeding onwards, brings the torpedo into explosive contact.

Airplanes have been suggested for use in attacking submarines by trailing under water deflected bombs. [Reference is made to United States Patent 1,218,586.]

Location of submerged "U" boats by use of kite observation balloons, towed from battleships, is one of the later developments of offensive.

From the high elevation, the observer controls an extensive sea area which permits the discovery of the submarine, the location being announced by wireless and the destroyers and seaplanes with depth-bombs called to the attack.

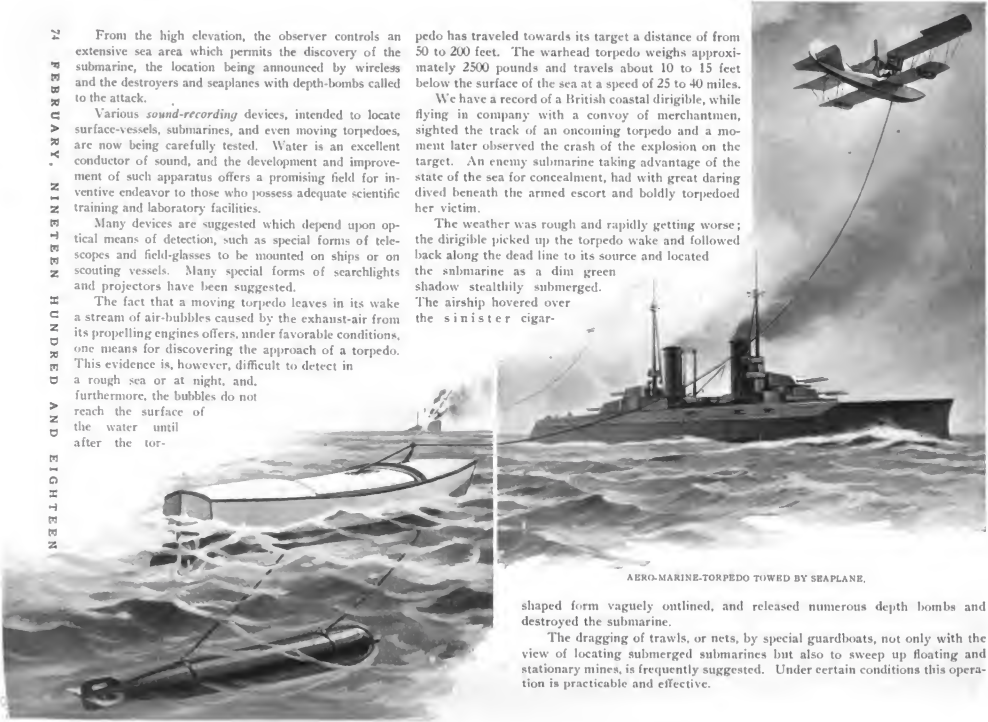
Various *sound-recording* devices, intended to locate surface-vessels, submarines, and even moving torpedoes, are now being carefully tested. Water is an excellent conductor of sound, and the development and improvement of such apparatus offers a promising field for inventive endeavor to those who possess adequate scientific training and laboratory facilities.

Many devices are suggested which depend upon optical means of detection, such as special forms of telescopes and field-glasses to be mounted on ships or on scouting vessels. Many special forms of searchlights and projectors have been suggested.

The fact that a moving torpedo leaves in its wake a stream of air-bubbles caused by the exhaust-air from its propelling engines offers, under favorable conditions, one means for discovering the approach of a torpedo. This evidence is, however, difficult to detect in a rough sea or at night, and, furthermore, the bubbles do not reach the surface of the water until after the torpedo has traveled towards its target a distance of from 50 to 200 feet. The warhead torpedo weighs approximately 2500 pounds and travels about 10 to 15 feet below the surface of the sea at a speed of 25 to 40 miles.

We have a record of a British coastal dirigible, while flying in company with a convoy of merchantmen, sighted the track of an oncoming torpedo and a moment later observed the crash of the explosion on the target. An enemy submarine taking advantage of the state of the sea for concealment, had with great daring dived beneath the armed escort and boldly torpedoed her victim.

The weather was rough and rapidly getting worse; the dirigible picked up the torpedo wake and followed back along the dead line to its source and located the submarine as a dim green shadow stealthily submerged. The airship hovered over the sinister cigar-shaped form vaguely outlined, and released numerous depth bombs and destroyed the submarine.



AERO-MARINE-TORPEDO TOWED BY SEAPLANE.

The dragging of trawls, or nets, by special guardboats, not only with the view of locating submerged submarines but also to sweep up floating and stationary mines, is frequently suggested. Under certain conditions this operation is practicable and effective.

It will be seen that each of the above methods, however useful, has its limitations, and scientists and inventors should apply themselves not only to the task of improving these, but also of finding supplementary methods and devices.

(*b*) Protection of Cargo-Carrying Ships by Nets or Screens

Many designs of such devices are suggested, and most of them are intended to be attached to the hull of the vessel to be protected. Many other suggestions along these lines, and differing only in some of their minor characteristics from the foregoing, have been received by the Board. Up to the present time not one of these proposals involving screens of any kind has received the approval of the Navy Department or of the Merchant Marine. The principal objections offered to these devices are that they are heavy, difficult to hold in position, unmanageable in a heavy sea, and that they interfere with the speed and with the ability of the vessel to maneuver. The undeniable evidence which has been accumulated during the past few months of submarine activity has demonstrated that the immunity of a vessel to submarine attack is dependent very largely on its speed and also its maneuvering ability. The percentage of vessels having speeds of 15 knots or more which have suffered from submarine attack is very small, while the losses of slow vessels, whose speed is less than that of a submerged submarine, is practically one hundred per cent. of those attacked. Many of the suggested devices would prevent the launching of life-boats or rafts from the vessel to be protected. It is barely possible, however, that there may be developed some form of this general plan which will be found practicable. In no other field have so many suggestions or so many duplicate inventions been presented to the Board.

As far back as 1877 a patent was issued containing the following paragraph:

"The nature of my invention consists in combining with a vessel a sectional reticulated shield or guard, suspended at a suitable distance from the hull of the ship, and partly or wholly surrounding the same, which shield extends downward a sufficient distance below the water-line to arrest a floating torpedo or explode one attached to an attacking vessel."

From that time until the present day many designs have been made, tried, and discarded. It is well known that a shield of sufficient strength and proper design will stop a torpedo, explode it, and render it harmless to the hull of a vessel, if the shield is a sufficient distance away. This distance is generally conceded to be about 30 feet. However, it depends very much upon the strength of a vessel's hull and the details of design made to localize the damage.

It has been the aim of all navies to do away with any form of shield or net protection, as in action, speed and maneuvering qualities are imperative; and generally in war time a fleet depends for a great part of its tactical value upon its ability rapidly to change its base. Modern naval construction is made to allow torpedo attack without disabling the vessel or preventing her from continuing the fight and eventually reaching her home port. It is known that in the present war battleships have been torpedoed more than once in the same fight, continuing the battle and arriving home at a fair rate of speed.

One of the great shipyards in England is interested in a torpedo defense pontoon supported screen that has been favorably noted in the American scientific press.

This device is not a part of the ship nor attached thereto, but provides a floating spar-like pontoon with a full length sheet steel flexible apron. These screens can be towed by the slower ships when moving thru mine fields or submarine zones, giving extensive broadside protection.

The pontoon screens can be towed as separate units by tugs or trawlers—and the defended ship can move safely forward, protected by these flanking screens.

The speaker will be glad to send to any engineer interested in the further development of this line of defense an illustrated booklet on "Submarine Problems and Torpedo Defense."

[Reference is also made to United States Patents 1,219,879 and 1,171,153.]

(*c*) Protection Thru Invisibility

The point of lookout on a submarine being close to the water, the position of a vessel at a distance can be determined only by observing its smoke, which floats high in the air. Improved smokeless combustion is therefore desirable. Relative invisibility may also be afforded by methods of painting.

A method of camouflage to create suddenly a fog cloud about a ship is made possible by an arrangement of pipes running along outside the length of the hull, parallel and near to the keel and connected up to the steam boilers. By quickly opening the control valve the steam pressure vents *thru small openings in the pipe* and rises as a fog cloud, instantly enshrouding the ship and confusing the submarine as to aim and direction. This is one of the many patents pending, and is mentioned only to encourage our engineers and inventors to further activities.

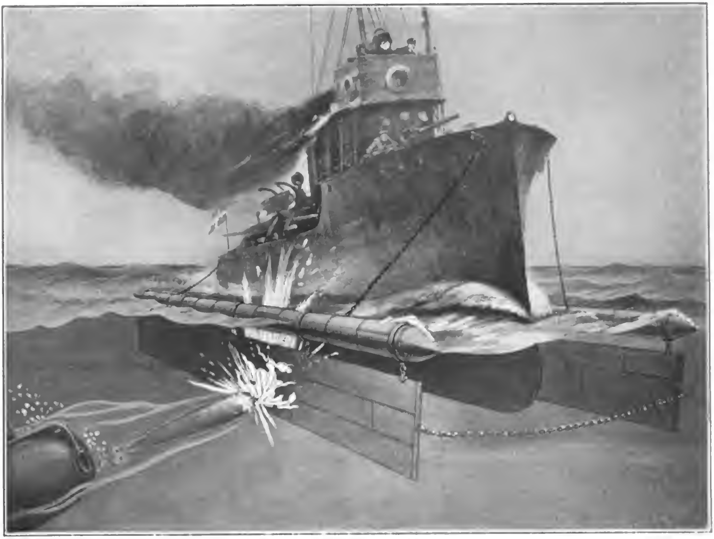
It is possible and desirable, if ship design prejudice could be overcome, to build a low visibility hull by reducing or eliminating the masts and spars and laying the funnels horizontal near the deck levels, supplementing the draught by further arrangement of blowers.

In the earlier days of the war, submarines have been lured into close range by screening the deck guns of merchant steamers and liners and by false rigging destroyers to simulate helpless sailing craft, but this deceit is increasingly difficult to accomplish as the later "U" boats mount powerful long-range guns.

(*d*) Destruction and Blinding of the Submarines

A *rapid-fire gun* is effective when the submarine is seen within accurate range of the gun; but the target is so small that it is difficult to hit.

The *powerful effect* of any *submarine explosion on all neighboring bodies* provides a simple means of *destroying or crippling* an undersea boat. Once it has been even approximately located, the setting-off of a heavy charge of high explosive, well submerged in the vicinity of the submarine, will bring about this result.



TORPEDO DEFENSE BY PONTOON SUPPORTED SCREEN.

A simple type of selective depth-bomb has already been described, and the news items of destruction of enemy submarines by this method of attack gives encouraging indication that in this device we have a weapon that spells the doom of the U-boat. [Reference is made to United States Patent Application Serial 161,874.]

In certain areas, a quantity of heavy, black *petroleum* or similar substance which will float on the surface of the water has proved an effective means of clouding the optical glass in the periscope's exposed end.

This spreading of oil upon the troubled waters results, however, in a waste without commensurable result, as a recent device operated from inside the submarine permits of the perfect cleansing of the periscope's outlook glass by projecting against the oil smootch a pressure jet of gasoline or other wash. [Reference is here made to United States Patent 1,222,156.]

Under favorable conditions of wind and position, many vessels have saved themselves from torpedo attack by the production of a *smoke screen*. This may be formed either by incomplete combustion of the oil used for fuel by most naval vessels, or it may be created by burning chemicals, such as phosphorus and coal tar, or mixtures in which both of these and other materials are used.

After hiding itself from the submarine in a cloud of dense smoke, the vessel, if possessed of sufficient speed, may be able by a quick maneuver to change her position and escape before the submarine is able to discharge a torpedo.

The serious fault with this plan has been the accidental of windage, for it is apparent that if the wind blows from the direction of the submarine toward the ship she cannot hide quickly in her smoke screen, which is blown away from her.

An improvement of great value meets this need by use of smooth-bore deck guns discharging smoke shells against the submarine, which puts the enemy into a murk screen, permitting the merchant ship to escape or by change of course to attack the submarine and sink it by gunfire or ramming.

[Reference.—U. S. Patent Application Serial 195,-289.]

MINES AND TORPEDOES FOR NAVAL OPERATIONS

(*e*) Mines

Ever since the first use of gunpowder in the prosecution of war, mines and torpedoes have received great attention, both from the warrior and the inventor. Mines are either *fixed* or *floating*. The *fixed or stationary submarine mine* is fired by contact, electricity, timing device, or fuse. Such mines, which are extensively used by all navies, are rugged in design and may contain large charges of explosives. They are placed in position by especially equipped mine-laying vessels. Such a mine is provided with an anchoring device.

Floating mines differ from fixed mines in that they are unanchored, and, unless guard boats are at hand to warn friendly vessels of their proximity, may be as dangerous to friend as to foe. Such mines must be, according to laws of war, designed to become inoperative within a few hours after being set adrift.

The submarine has been successfully used as a mine layer and can enter defended sea areas and plant mine fields, uncharted and undetected. An elaboration of this function is noted in the possibility of submarines liberating containers of asphyxiating gases or smoke clouds from a position under the enemy battle fleet or surface ships and causing tremendous loss and havoc.

The defense against such surprise being eternal vigilance and full protection to the crews by night and day use of gas masks.

[Reference is made to United States Patent 1,222,-498.]

Harbors and waterways are not entirely safe from submarines that may enter submerged below the mine flotation level to avoid contact, and then rise to the surface for observation and bombardment or to release aeroplanes for distant depredations.

A proposed harbor defense against the enemy submarine awash or surface battle craft, comprises a method of gas or smoke cloud liberation from containers anchored to the bottom and electrically controlled, or detonated, from shore observation stations, thus involving the enemy in a murk or incapacitating gas cloud.

This camouflage mine field could be cheaply created and would be easy to install, and while depriving the enemy of power of observation or fire control yet disclosing his position by his military mast tops rising above the low hanging cloud and permitting the shore batteries to deliver their attack.

[Reference—U. S. Patent Application 155,316.]

(*f*) Torpedoes

The *modern submarine torpedo* is about 20 inches in diameter and 20 feet in length; is *self-propelled; is not steered by magnetic means;* and keeps a fairly accurate course for several thousand yards at an average speed of more than *30 miles an hour*. Its *weight is approximately a ton and a quarter;* and, when traveling at normal speed, possesses great *momentum*—in fact, in one case, when the high explosive charge in the " warhead " failed properly to detonate, the body of the torpedo penetrated the steel hull of the ship attacked. Torpedoes are also provided with means to more or less effectively cut thru screens, nets, or guards placed in their path.

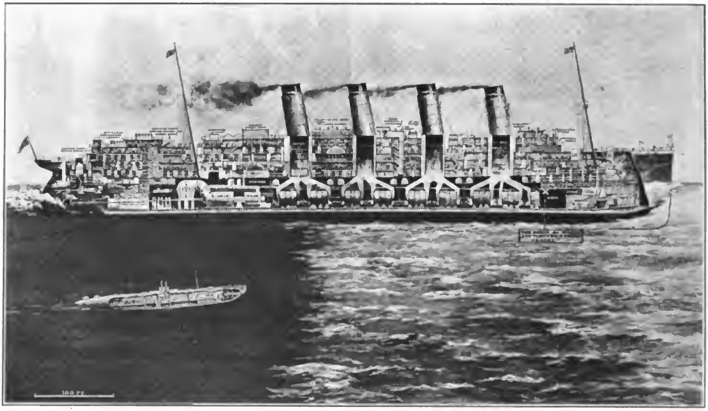
A torpedo is projected from a submarine or other vessel by means of a special form of tube or gun. A small charge of gunpowder or compressed air is employed to start the torpedo, after which—if of the usual self-propelling type—it is driven thru the water by its own compressed-air motor, the air being supplied from a strongly built reservoir within the body of the torpedo itself. The torpedo is kept upon its course by a *gyroscope* steering mechanism, which is *immune to outside magnetic disturbances.*

The detonation of the torpedo is accomplished thru a mechanism placed within its warhead; and if the torpedo is either *abruptly diverted from its course or is checked in its forward motion, the firing device,* which is *operated by arrested momentum* rather than by any form of a projecting firing-pin, instantly ignites the heavy charge of explosive contained within the warhead. The *explosion,* if it takes place *within twenty feet of the vessel,* will usually *rupture the ship's plating,* because of the terrific blow transmitted thru the water from the point of the explosion to the ship's side. The *depth* at which a torpedo travels is usually between 10 and 15 feet below the surface.

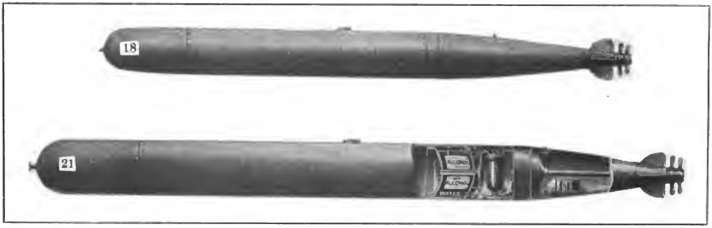
CONFINING THE SUBMARINES

The question as to why submarines are not destroyed before they reach the open sea is a most natural one, and the best answer which it is possible to give, according to the officers of our navy and those of the foreign commissions who have visited this country, is as follows:

The submarine bases are very strongly protected by land batteries, aeroplane observers, and large areas of thickly mined waters extending to such distances that the largest naval gun cannot get within range of the bases. In spite of these protections, there is now going on a continuous attempt on the part of the Allied navies to entrap or otherwise defeat the submarines as they emerge from the protected areas. Nets are laid and as promptly removed by the enemy, whose trawlers are in turn attacked by our destroyers. The design of these nets and the detailed arrangement of their fastenings and attachments offer a broad field for invention, but it should be remembered that they must be capable of being used in waters in which there is a tidal current running from two to five miles per hour. Many suggestions for "bottling up" these bases have been offered, but, as will be realized, it is not desirable to publish information which would indicate even in the smallest degree this country's plans.



UPPER: COMPARATIVE SECTIONAL VIEW OF "LUSITANIA" AND ENEMY SUBMARINE
LOWER: WAR TORPEDOES—18" AND 21" DIAMETER.



Ambitious plans have been presented suggesting a great bomb curtain sea net, strung in sections miles long and pendant 200 feet deep, to close the North Sea from Scotland to the three-mile limit off the Norway coast.

The difficulties are stupendous and the cost would be tremendous, but many important engineers and the scientific and technical press express hopes that it will yet be done.

This great net would be float-supported, and at the crosswires of the 20- to 30-foot meshes there would be attached explosive contact bombs to destroy any submarine that would nose in.

[Reference is made to United States Patent Application Serial 157,389.]

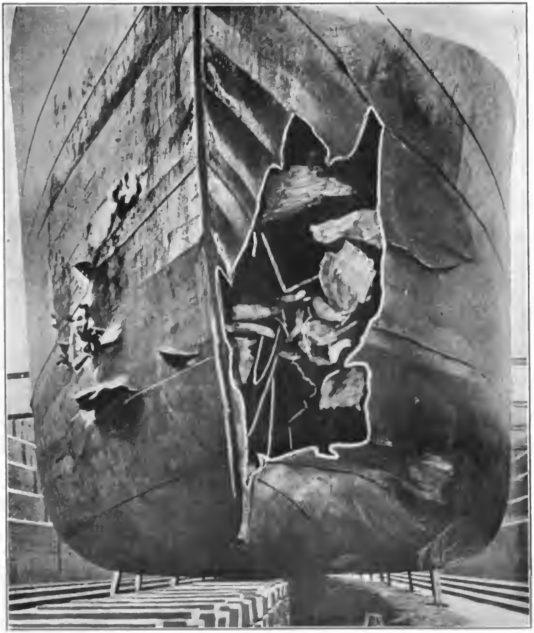
SHIPS AND SHIPBUILDING

Many suggestions are made for ships of ***unusual form*** to provide for safety in case of a torpedo or mine exploding near or against the hull. Most of these plans are an elaboration of the usual water-tight bulkhead construction now required as structural design for all modern ships.

The *multiplicity of water-tight compartments* in any hull design tends to add to the vessel's *safety.*

explosion of a mine or torpedo may be greatly diminished by special hull construction.

The incompressibility of water gives the required fulcrum to the explosion of the warhead and the hull plates break inward under the impulse of the expanding white hot gases. It therefore follows that the destructive effect would be minimized in direct proportion to the non-resistance of the fulcrum. To accomplish this desired result an ingenious method is under patent which provides perforated pipe line outlets parallel to the ship's keel and connected up to the high pressure steam line.



EXPLOSIVE EFFECT OF TORPEDO AGAINST SHIP'S HULL—THE "NEBRASKAN"

The *modern tank steamer* used to carry fluid cargoes, such as petroleum products or molasses, is a *good example of this design,* which has been in general use for many years.

The explosion of a nearby submarine mine or torpedo frequently tears great rents in the ship's plating, in some cases opening a jagged hole ten feet or more across, but the destructive effect on the hull of a ship caused by the

Upon approach of a torpedo the steam is switched into the outlets and the rising zone of bubbles displaces

SUBMARINE AT DEPTH OF 30 FEET, PHOTOGRAPHED BY SCOUT AIRPLANE 60 FEET ABOVE SURFACE AND SUBSEQUENTLY DESTROYED BY DEPTH BOMBS.

the sea water and creates a froth mass of reduced resistance tending to dissipate the force of the torpedo explosion.

[Reference—U. S. Application Serial 201,949.]

In making reference to various patents and applications of devices, it is only intended thereby to illustrate types and general methods that the engineer and inventor may know in part what has already been done. Even tho some of these references may be to the 40,000 misconceived devices examined and unused, they have been helpful to the national cause by the patent fees expended upon them and as guides and guards to the inventors yet unborn.

MANUFACTURING IN RELATION TO BANKING, RESEARCH AND MANAGEMENT*

By WALTER RAUTENSTRAUCH, Consulting Engineer

PERHAPS there has been no other time in the life of our nation during which the social and economic problems confronting us have been so vital, so perplexing, and of such colossal magnitude as those which confront us now. Nor have there been such times as these not only to test the strength of our material resources, but also to prove the good and the bad in the articulation and functioning of the elements of our business system thru which our resources are created and distributed. Our engagement in this most gigantic of wars is serving not only to present new and more perplexing problems, but also to emphasize the needs and accelerate the demands for an entire reconstruction of our whole business and social relations. Not only are we compelled to bend every energy to carry to a successful issue a campaign for principles by which nations may live in harmony and peace, but circumstances demand that we also reconstruct the foundations upon which shall stand economic and social institutions capable of leadership in the new world which shall rise from the ashes of the old.

Under most unusual circumstances, therefore, are we required to seek solutions for difficulties which even in normal times would demand the keenest minds and the strongest characters to accomplish.

Many agencies, governmental, industrial, and corporate, are at work in an endeavor to adapt present facilities and create and operate new facilities for carrying on the business of war. Not only for war, but also for the many perplexing industrial, agricultural, and social situations incident to the problem of living, which the war has seriously disturbed. We have followed many of these activities in the columns of the press and marveled at accomplishments in the raising of funds, the extension of credits and the gathering of large forces of men. The recent campaigns for Liberty bonds and for the work of the Y. M. C. A. have inspired each one of us with feelings of pride and confidence. We are a united people, and we have demonstrated our ability to work together in the furtherance of a high ideal. The fibre of our national character is sound, and we will forge at the anvil of experience and sacrifice even stronger and more lasting bands of moral fibre and national strength. But, while our potential forces are matters of just pride, let us also be thankful that we are conscious of our weaknesses and inexperience and that we recognize the difficulties and failures which surround us. The many heated debates in the councils of our leaders and criticisms in the daily papers on the conduct of governmental and industrial affairs make us more and more conscious of the need of a business system which is more fundamentally sound and the need of higher ideals upon which such a business system may successfully be founded. We have long held the reputation for wastefulness which abundance of resources creates. The quick acquisition of wealth without the moral strength of character which arises from the toil and sacrifice of production has raised up many leaders who predominate the controlling forces of our civilization and tend to destroy the standards of service and create false standards of living. The reflection of these influences in the conduct of affairs has occasioned much waste in resources and effort and created many of these problems which confront us to-day.

But as we contemplate the many instances of waste in resources and effort which accompany our endeavor to carry this war to a successful issue we find that the inherent nature of the conditions by which these wastes occur is no different than that which many of us have observed in normal times, only in a lesser degree. These conditions have been pointed out so many times by able men in diverse paths of human endeavor that they need not be repeated here, and yet it seems that they need continual emphasis. It would seem that our failures reside in these particulars:

First. Individualistic effort as opposed to coöperative effort.

Second. An undue regard for the might of "purchasing" power as opposed to the might of "creative power."

Third. A lack of appreciation for science or the scientific spirit in the conduct of our business system.

The introduction of corrective measures which will enable us to counteract and reconstruct these tendencies reaches every field of human endeavor, and the very nature of the changes demanded positively indicates that this must needs be. We are dealing now with an attitude of mind, the creation of a philosophy, if you please, upon the foundations of which we hope to rear an economic and social machine which will withstand the onslaughts of a world catastrophe—indeed, by means of which such catastrophes may be impossible.

In every movement or effort to betterment there are certain avenues of approach or mediums of operation thru which most effective results can be accomplished, and as we review the problems before us and the particular institutions factoring therein, it seems that among these the manufacturing industries take a high place. Any right effort to place our wealth-creating agencies, as represented by the manufacturing interests, on a higher plane and in proper coördination with other controlling factors of our civilization will render a lasting service to mankind. A close analysis of the manufacturing problem will indicate that corrective measures must be applied both from within and without the immediate province of the enterprise. It will be our purpose to consider three particular avenues from which relief may come, and these are in:

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* Presented before Philadelphia Section of American Society of Mechanical Engineers, November 27, 1917, at the Engineers' Club.

First. The closer relation of our banking institutions to productive enterprises.

Second. The closer relation of our universities and educational institutions to the industries.

Third. A broader conception of responsibilities in the management of factories.

1. RELATION OF BANKING TO PRODUCTIVE ENTERPRISES

For many years the economics of barter and trade have so engrossed the interest of capital that the opportunity of profits in dealing with what others have produced has overshadowed any interest in the economics of production and the obligations of capital toward it. Wealth distribution and acquisition therefore have become of primary importance in our industrial philosophy, while the wealth-creating agencies have been factored to only a limited degree. Only as necessity has forced the issue, and not as a matter of fundamental policy, have the wealth-producing agencies been raised to the plane of excellence which their value demands. This attitude of mind is well reflected in the usual methods employed by banking institutions in extending their credit facilities to those engaged in productive enterprises. Because of its obligations to its depositors, the banks have had to have regard for the quick assets of the borrower, so that the acceptance of all customers' notes is primarily conditioned on this particular.

Indeed, sound banking demands the customer's liquidation of obligations at stated periods, and for this reason the customer's possession of quick assets has been the deciding factor in credit extensions. When we realize that about four per cent. of the daily business transactions of this country are conducted in money or currency and ninety-six per cent. are recorded in open account credits, checks, notes, and bills of exchange, and that a disturbance of this ratio, say a demand for ten per cent. cash settlement, will inaugurate a panic, we appreciate that emphasis in the matter of the borrower's quick reserves is well placed. Unfortunately, many of the banks in smaller centres have not demanded statements from borrowers, but have loaned money on an assumed knowledge of the condition of the borrower's affairs, and therefore have narrowed the margin of safe fluctuation of cash payment demands. The influence of the Federal Reserve Banks in the correction of this practice has been most wholesome. The obligation of member banks to certify to " the financial responsibility of the borrower, including a short general description of the character of the business, the balance sheet," when offering paper for discount has resulted in a more safe procedure in credit extensions.

Since the majority of borrowings are on single-name paper or notes issued against the general assets of the borrower, and the security of the credit of the country is to rest in large measure upon the paper held by the reserve banks, these precautions are the more significant. It seems, therefore, that, while emphasis is being placed on the borrower's ability to liquidate his obligations at maturity, this emphasis does not alone reside in the examination of books of account, but additionally in an assurance of the soundness of the borrower's enterprise. In the earlier regulations of the Federal Reserve Board it was provided that notes, drafts, and bills of exchange were not acceptable for rediscount, when funds applied to " merely investments." Later regulations, however, provided that, while bills were considered eligible for rediscount which were to be used " in producing, purchasing, carrying, or marketing goods in one or more of the steps of the process of production, manufacture, and distribution," it is conceded that such funds obtained may be used for other purposes than those above specified: " if the borrower shows, by statement or otherwise, that he has a reasonable excess of quick assets over his account liabilities in open accounts, short-term notes or otherwise." More recently the Board has departed from these rigid requirements and has simply recommended that member banks require such statements from their customers as will satisfy the above requirements as a basis for the certification of the bank's officer that, to the best of his knowledge and belief, the bill was issued for a purpose that made it eligible for rediscount; that is, the bill was issued for business of a current nature and not merely an investment.

Thus, while it is seen that the Federal Reserve Board is causing our banking institutions to have more regard for the borrower's ability to liquidate his banking obligations at maturity, its influence is such as to point out that this ability does not alone rest in the possession of quick assets, but that it is also dependable on certain factors which condition the life and prosperity of the enterprise itself. Wealth-creating ability as represented in factors which every engineer understands is being appreciated, together with purchasing ability as represented in readily convertible assets. The inauguration of credit control through the medium of the Federal Reserve

Banks, therefore, has not only served to promote a more sound banking policy in the matter of credit extensions, but it is also causing the more progressive bankers seriously to view the whole banking problem in relation to industrial enterprises. In other words, there is being created a larger sense of obligation and of opportunity to serve the industries that thru the closer coöperation of the two both may grow into stronger institutions.

Not only has this influence been working in the relation of banks to manufacturing industry, but also in their relation to the agricultural interests. In this instance is it particularly true that the foundation of credit must rest on anticipations which are realized thru sound business methods, and therefore the banks are compelled to interest themselves in this phase of the borrower's soundness.

As evidence of this latter influence I quote from a recent issue of the *Annals of the American Academy of Political and Social Science*. In an article on "Lessons in Solving Labor, Credit and Other Production Problems," by A. T. Grantham, the author, in referring to the way in which the Commonwealth of Massachusetts has dealt with the problem of helping the farmer in this crisis, says: "Several of the banks have opened special farm departments and employed men whose business it is to investigate the applications of farmers for credit. The Plymouth Trust Company, of Brockton, has for two years employed two men, graduates of the Massachusetts Agricultural College, to aid the farmers in applying business methods to the business of farming. The object of the directors of the institution was to get acquainted with them so as to make a businesslike application of credits to those engaged in this important industry. This bank has helped the farmers of their vicinity to buy seed, livestock, etc., and stimulate production by offering prizes to the young people on the farm. It is showing the farmer how to keep cost accounts and how to make cost statements; in short, to know his business both from the technical and from the business standpoint. To *worthy* persons they stand ready to make a small loan to be used for construction work or for improvement *under the supervision of the bank's field agent.* Every banker will ask himself. Does it pay? It has cost the Plymouth Trust Company $4000 a year net to supply this service to farmers in and about Brockton, but as a result of this and similar activities the deposits have increased in the past five years from $400,000 to $3,000,000."

This instance of coöperation between the bankers and the productive industries is evidence of an awakening to opportunity in which we may take great hope. Not only is there a recognition of a "more business-like application of credit" which rests upon the fundamental laws conditioning the prosperity of the wealth-creating industries, but there is also evidence of a real spirit of interest and helpfulness, in that there is maintained a personal and intimate contact thru scientifically-trained bank representatives.

In the field of industrial banking we have also just reason to feel that an appreciation of the broader field of usefulness of banking facilities is being felt. Under wise leadership the National City Bank of New York has inaugurated an industrial service department which it is believed will have a most helpful influence in the field of industrial development. In setting forth the ideals of this new field of service, Mr. Schwedtman states in *The Americas* of July, 1917, that:

"The managing executive of commercial organizations has for a long time felt that the professional banker often fails sufficiently to interpret statement sheets in terms which show to best advantage the assets which to him are of greatest importance. On the other hand, the banker has sometimes been impatient with the commercial manager who does not comprehend to the full extent the essential necessity of well-defined limits of certain ratios between quick assets and current liabilities for a safe banking loan." . . .

"A large part of our commercial life is operated upon an industrial basis, and the banks of the country must organize themselves to render credit-extension service sufficiently interpreted in the terms of 'Plant and Equipment,' 'Personnel of Officers,' 'Labor Conditions in the Factory,' 'Type and Quality of Product,' 'Profit and Loss Based on Scientific Cost." . . .

"One lesson which the present world-struggle has impressed upon us is the fact that success, whether in the pursuits of peace or war, demands organization. The military organization, with its requirements of blind obedience, is not efficient in peace pursuits. In the organization of a connecting link between our banking and industrial interests there must be a means for intelligent coöperation based on mutual understanding which eliminates blind adherence to 'rule-of-thumb' on the part either of the commercial organizations or the banking institutions." . . .

"Perceiving this need, the National City Bank of New York, in establishing a new department of 'Industrial Service,' hopes not only to increase the usefulness of its banking facilities to business by adding to its means of recognizing and crediting merit where credit is due, and thus to blaze the way for more constructive coöperation between banker and client, but also, by placing the emphasis on better methods of doing business, to help swell the tide of interest in scientific cost-keeping and more efficient management regarded by keen observers as essential to our success in the world-wide economic struggle certain to follow the present war." . . .

"Looked at from the bank's viewpoint, the Industrial Service Department should supplement the present credit information with facts and angles on the condition of prospective customers which should be of the greatest value to the officers of the bank in deciding the momentous question of whether credit shall or shall not be extended. It should, in short, doubly insure the bank against taking on, unsuspectingly, industries which are potentially, if not actually at the present moment, poor risks. It may not be generally recognized as yet, but it is a fact nevertheless, that all human activity is governed by a fairly well-defined set of principles or laws. These it is the business of the industrial engineer to understand. In proportion as he does understand them, and is able to trace their manifestation, is he able to diagnose the condition of the industrial 'patient' and to predict, almost with the precision of an astronomer in forecasting an eclipse, the outcome of events if the policies now in force are persisted in.

"That a business to-day is prosperous and can show a favorable balance sheet, that it now enjoys the best of credit locally and is by all who have relations with it held in high esteem, is certainly useful information; but it is by no means assurance positive that two, five, or ten years hence that business will still be in the running. Every institution, even as every individual, contains within itself the potentiality of better things or worse, and just as the sea is always calmest immediately before a storm, so the business apparently smooth and serene to-day may to-morrow or a year hence begin to develop the disorders which foretell the coming decline. The trained industrialist is not deceived by surface indications, but, like the skilled navigator, is able to look thru and beyond and perceive an impending crisis in affairs long before there are book evidences of it.

"Nor is the opportunity for influence limited to applicant plants. Established customers, indeed, offer even a bigger field. If it is important that the bank extend its facilities to sound and ably conducted enterprises only, it is no less important that those plants already enjoying support shall continue to be worthy of it. The possibilities for rendering constructive service of a high order to the bank's 'family of industries,' by gaining their more intimate acquaintanceship, is limited only by the ability, sincerity, and energy of the bank's representatives—those whose function it really is to 'humanize financial relations.'

" . . . The chief effort, therefore, of 'Industrial Service' will be exerted along strictly coöperative and educational lines.

"What an infinite deal can be wrought thru the channels of education! Ignorance is our common foe; if we knew better, we would do better. Yet so vast is the field of human knowledge, so manifold its ramifications, that a man might easily spend a lifetime investigating one single subject and then not get to the bottom of it. Coöperation in the interchange of knowledge and ideas, therefore, is an absolute essential to progress, and the individual, whatever his station in life, who shuts himself off from his fellows, who assumes that he knows all there is to know, or at least all that is worth knowing about his specialty, is standing in his own light. He not only robs himself but all society, and the loss is in proportion to his responsibility." . . .

"Last, but by no means least, we will do what we can to coöperate with educational institutions and movements which are wrestling with the great problem of increasing our supply of competent managerial material. 'As the manager, so the factory.' The future of American industry is going to depend a vast deal on how successful we are in training our young men for industrial leadership."

With the permission of Mr. Schwedtman is presented herewith a diagrammatic form, the embodiment of the new Industrial Service Department, in the scheme of the bank's organization.

A study of this chart will show quite clearly the thoro manner in which the bank is prepared to be of specific help to the manufacturer in every field of technical and financial service. A new industrial philosophy is springing into being, and the spirit of intelligent helpfulness is guiding our endeavors more firmly to establish the foundations of our national welfare and growth.

2. THE RELATION OF OUR UNIVERSITIES AND EDUCATIONAL INSTITUTIONS TO THE INDUSTRIES

It it impossible to record the development of our manufacturing institutions without bearing testimony to the labors of the scientists whose investigations and researches have been the very corner-stone upon which the industries are founded. While this is so obviously true, its significance is not always realized, and there has accordingly developed in many quarters a departure of the industry from the help of the scientist and a failure of the scientist to coöperate with the industry. Consequently the scientific spirit or attitude of mind is lacking in many of our industrial institutions, and the engineering and scientific schools where the activities of the scientist are largely confined have not always embodied those methods of operation which make apparent their industrial usefulness.

The time has passed, if indeed it ever has been, when the industries and the engineering schools can come to their full possibilities without close coöperation. The separation of the two institutions, whose technical interests at least are one, has been a loss to both in spite of the rapid development of each. The men coming from our schools have not been as well prepared for immediate usefulness as they might have been, and the industries have failed to profit by the results of scientific discoveries which have never become known beyond academic circles. In fact, one of the greatest services to be rendered by our engineering schools lies not so much in the discovery of new facts and principles as in the introduction in the

ORGANIZATION OF INDUSTRIAL SERVICE DEPARTMENT NATIONAL CITY BANK OF N. Y.

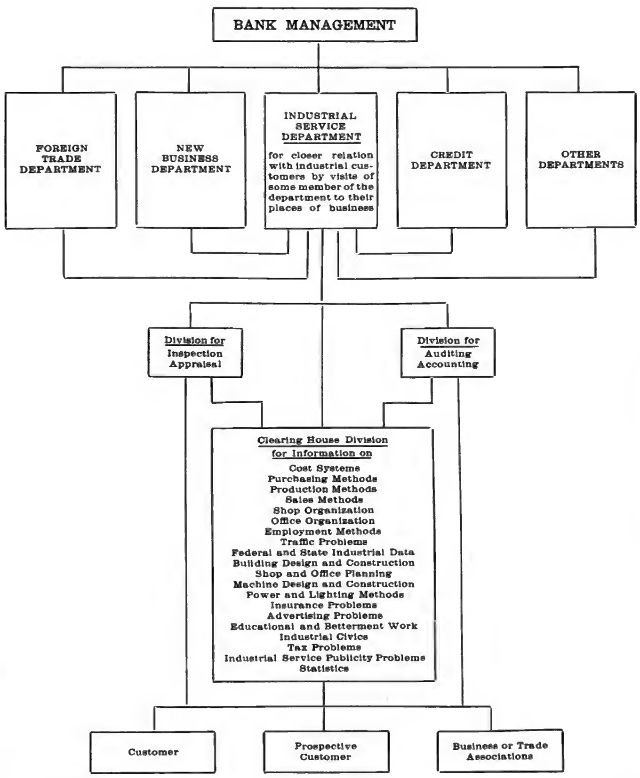

BANK MANAGEMENT
FOREIGN TRADE DEPARTMENT
NEW BUSINESS DEPARTMENT
INDUSTRIAL SERVICE DEPARTMENT
for closer relation with industrial customers by visits of some member of the department to their places of business
CREDIT DEPARTMENT
OTHER DEPARTMENTS
Division for Inspection Appraisal
Division for Auditing Accounting
Clearing House Division for Information on
Cost Systems
Purchasing Methods
Production Methods
Sales Methods
Shop Organization
Office Organization
Employment Methods
Traffic Problems
Federal and State Industrial Data
Building Design and Construction
Shop and Office Planning
Machine Design and Construction
Power and Lighting Methods
Insurance Problems
Advertising Problems
Educational and Betterment Work
Industrial Civics
Tax Problems
Industrial Service Publicity Problems
Statistics
Customer
Prospective Customer
Business or Trade Associations

FIG. 1

industries of many scientific discoveries dormant in the archives of the scientist, the commercial possibilities of which have never been appreciated. The patient search for scientific laws and principles underlying industrial processes and economic relations by those skilled in methods of research, and, moreover, the careful and judicious application to an almost limitless field of human endeavor of the already established facts and laws which have never been put to effective use, together with the preparation of highly skilled engineers capable of making and supervising these applications, is a plane of usefulness to which our universities must rise that they may take their proper place in the development and growth of our nation. Here, also, the obligations of this development lie both within and without the academic walls.

While engineering is highly technical, it is essentially an economic study. Just as the banker operates thru the medium of bonds and stocks and is successful as he understands the laws which condition their value, so the engineer operates thru materials, machinery, and men, and is successful as he understands the laws which condition the existence and prosperity of manufacturing institutions. While the most direct effect of engineering education in the past has been its contribution to purely scientific facts and principles, to the exclusion from consideration of those conditions under which these may be commercially useful, the economic necessities of the industries demand that we modify both the content and the spirit of the subject-matter handled and more closely parallel the economic requirements of engineering practice. The tendency in our engineering schools to-day, therefore, while emphasizing the necessity of excellence in the treatment of scientific facts and methods of analysis, must be increasingly toward that commercial and economic treatment which is so essential to an adequate knowledge of the use of science in engineering service. We find, accordingly, that those subjects in engineering instruction which were formerly thought to have their sole foundation in the sciences of physics, chemistry, and mathematics, and which conveniently admitted of formulated treatment, must be modified in their presentation to the inclusion of questions of cost and the influences of economic environment. Tho it was once believed that, because engineering practice required a knowledge of scientific facts and principles, instruction in these alone was a sufficient preparation for the practice of the profession, it is realized that this is not sufficient, and that a knowledge of the economic adaptability of facts and principles is of equal, if not of greater, importance to an adequate understanding of engineering practice.

Accordingly, while formerly a student was taught to manipulate with the mathematics of thermodynamics in explanation of the behavior of steam in an engine, and instructed in the principles of performance of water wheels thru the sciences of hydraulics and mechanics, and to compute the stresses in a framed structure thru the principles of graphical statics, he must be taught, in addition to these, that the cost at which power may be generated is determinable by clearly defined principles and laws by means of which he may decide whether a steam-power plant or oil-engine installation or water-power development, each with a given type of housing structure, is capable of producing power in this locality or that locality with minimum cost of investment, depreciation charges, and cost of labor and materials in operation to satisfy a real demand and justify its creation. He must learn not only how a machine pattern is made by some method selected for demonstration by the instructor, but also that it may be made in a variety of ways, each of which is justifiable according to the quantity of production, demand for rearrangement of parts, adaptability to economic methods of moulding, and to other conditions affecting the cost of producing castings by it. Not only should he learn to determine the proportions of machine parts to suit the loads imposed upon them, but also that the proportions must be modified to permit the part to be duplicated in a series of sizes of a given class of machine, or to facilitate founding and machining operations, that the completed machine may be supplied to the market at a price and in competition with other manufacturers of the same class of goods.

These attempts of our engineering schools in the past to make the instruction in engineering subjects more nearly representative of standard practice have met with more or less success, depending on the closeness of contact of the instructors with engineering practice and their ability to incorporate the spirit of engineering in methods of instruction. The effect of a proper amalgamation of the purely scientific and technological aspects of engineering with the economic and commercial principles upon which successful practice is founded is to create in the student that sense of proportion and judgment which tends to economize his efforts in contributing to scientific progress and inventions. Not only will he know how to proceed to judge the scientific feasibility of a project, but also to determine what commercial limitations make a scientifically possible project impracticable; and, moreover, if he has that rare spirit of inquiry developed by proper methods of instruction, he may be able to determine that commercial limitations in a given field of practice exist because of an insufficient or entire lack of knowledge of scientific facts and principles, and thus be led to an investigation of scientific foundations the successful issue of which may be a most important contribution to the revolution of engineering practice in a given field. Perhaps the most striking instance of this latter kind of scientific investigation is that conducted by the late Dr. Fred W. Taylor. His studies in the ancient art of cutting metals and the discoveries resulting therefrom have not only caused the redesign of nearly all of our metal-cutting machines to the improvement of their functional characteristics, but has completely revolutionized the methods of machine-shop management, the influence of which is felt in many quarters not at all concerned with engineering processes.

But this attitude of mind necessary to a proper conduct of an educational campaign for industrial betterment cannot develop without the coöperation of the industries themselves. We may inquire, therefore, into the nature of this coöperation demanded and the ways in which it may be accomplished.

For many years we have been accustomed to look upon the work of the Department of Agriculture as rational and necessary to the development of our agricultural resources. Thru the operations of its Agricultural Experiment Stations in every state in the Union, its scientific laboratories and the work of its trained investigators at Washington, and more recently thru its trained agricultural agents in every district of the nation, the department has been of invaluable help in promoting the most efficient methods of crop and livestock production. During the present year the budget of the Department calls for an expenditure of over $29,000,000 and will employ over 7000 workers in all lines of research and the introduction of better farming methods. This expenditure of money and labor will effect the better use of $50,000,000,000 worth of investment in farm property and livestock and serve to increase its productivity, which approximately amounts to

Dairy products	$750,000,000
Wool products	80,000,000
Poultry and eggs	250,000,000
Honey and wax	6,000,000
Domestic animals	2,000,000,000
Farm products, such as wheat, corn, etc.	7,000,000,000
Or a total of	$10,086,000,000

It is also effective in the better education of over 7,000,000 farm workers on whom dependence in better farming methods must be placed.

When we seek for the same evidence of coöperation between science and industry in the manufacturing field, we find that no organization of this sort is to be found. There is, of course, good evidence of individualistic effort in many quarters, both in research and in the promotion of better methods of production, yet there does not exist the coöperative effort which the importance and value of the industries demand.

It may safely be estimated that the capital invested in manufactures is perhaps $25,000,000,000, and the annual value of manufactured products of all sorts nearly $30,000,000,000. Approximately 8,000,000 people are employed in the strictly manufacturing industries, and the value added thru their labors is nearly $12,000,000,000.

Surely the economic importance of our manufacturing interests, as above reviewed, indicates a real demand for organized scientific effort to conserve and develop to its fullest possibilities this strong right arm of the nation.

Those industries which could afford industrial research laboratories have demonstrated their value beyond doubt. The wonderful laboratories of the General Electric Company, the Eastman Kodak Company, and others with abundant means are counted among the big assets of the organization, since they have materially contributed to the strength of these institutions.

It is such times as these, when all industries, both great and small, are depended upon for the creation of those products which our recently established $19,000,000,000 credit hopes to purchase, that we realize the need of helping those who surely need the assistance of industrial development laboratories but cannot afford the investment or maintenance charges. In this connection it is extremely interesting to note the following paragraph from a recent issue of a New York paper:

" COÖPERATION IN RESEARCH

"*British Way of Bringing about Progress in Industries*

" Realizing that many industrial firms are barred from the benefits of scientific research into their particular lines of activity by the great cost, reports Consul Franklin D. Hale, Huddersfield, England, the Committee of the Privy Council for Scientific and Industrial Research proposes the introduction of the coöperative idea. In this way a firm that is unable to bear the entire expense of research could contribute to the cost and share in the benefits accruing to an industry as a whole. It is planned to establish trade research associations in England, to be formed as needed for each industry or group of industries, and aided by certain funds which the committee has in charge. One association is about to be organized for the cotton industry, and others will be formed as soon as possible for the wool, flax, oil, and photographic industries.

" The work that has already been accomplished thru the committee's efforts, according to Mr. Hale, includes the discovery of three kinds of optical glass, the investigation of light alloys for use in aircraft, and the production of a new hard porcelain from purely British raw material. Researches into the recovery of tin are expected to save that industry a very large amount each year."—*New York Times.*

All phases of this subject cannot be considered, but it is sufficient to point out that the particulars of this need for industrial betterment seem to reside in the creation of industrial research facilities and in the training of men thru whom research may be conducted and introduced in the industries. In the last analysis the successful issue of this project must rest primarily upon the training of men, for not only must better production methods be discovered for particular industries, but there must also be those who shall actually introduce and operate them.

Quite clearly, therefore, does there seem to be an obligation resting on the universities and the industries which can only be accomplished on a high plane of coöperation.

In what form shall this coöperation exist, and what shall be the specific means thru which it shall become effective?

Of the several possibilities which suggest themselves, it seems that most fruitful results will follow from the establishment at our universities, located in industrial centers, of industrial development laboratories, to which all industries, both great and small, may have an equal access. The endowment of these laboratories that they may be independent of any income from specific industrial interests is absolutely essential to their free development and operation. With the establishment of such facilities there can be little doubt but that the great potential energies of our universities can be made directly available to the improvement of industrial processes. Not only will this be of benefit to the industries, but it also will react favorably to the universities and stimulate productive scholarship and scientific research which will be felt in every field of human endeavor. It is believed that these laboratories will soon demonstrate their usefulness in the manufacture of every commodity, and, altho their introduction into the university organization must be gradual, it will not be long before the demands of the industries will require an equipment and organization which will compare favorably with that now possessed by the agricultural interests. A conception of what these laboratories may be is shown in Fig. 2. The group of buildings has been arranged by a body of interested men to aid in the realization of how this sort of project may ultimately develop, and is only intended to serve as an objective toward which we should strive.

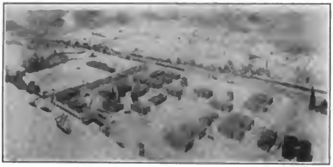


FIG. 2

Together with the investigation of the technical problems of the industries, these laboratories must also fully consider the methods of organization and management by means of which the results of industrial research may be effectively employed in the industries. Therefore it is believed that such a project as this should also serve to promote better methods of management thru which industrial process development may most effectively be realized.

3. BROADER CONCEPTION OF RESPONSIBILITY IN FACTORY MANAGEMENT

So much has been written on the problems of production, both in regard to their general aspects and in relation to their specific solutions in particular cases, that it seems as if enough had already been disclosed upon the basis of which successful procedure in particular industries might be formulated.

For the past twenty-five years there have been accumulated volumes relating to details of facts, methods of analysis, and routine organization plans for the effective conduct of tool-rooms, stock-rooms, planning departments, general offices, specific production departments, and for the efficient use of men and machines. There is scarcely an industry about which literature of the above sort cannot be found. Unfortunately, however, we are so constituted that the creation of this literature is not alone sufficient to stimulate improvements in methods of production. In spite of the fact that information on methods of scientific cost-keeping can be had almost for the asking, the Federal Trade Commission has reported that only ten per cent. of our industrial establishments have a cost system worthy of the name. This lack of cost information is indicative of inefficiencies in processing and management which can be effectively controlled only thru a knowledge of cost factors. Thus it appears that there is real need for an educational campaign which shall seek to establish as a basic principle in American industries those methods and policies which have been so successfully tried in particular cases. And this campaign must be waged among those who are in positions of authority, who exercise the managerial function and are responsible for the policies which govern the business over which they preside. Engineers discuss these things among themselves, and institutions presided over by engineers benefit by these discussions, but there is not that freedom of association between engineers and financial interests which dictate policies to create a scientific attitude of mind in the management of affairs. While the engineer is in some measure responsible for this condition, nevertheless it seems that ownership interests must evidence a real desire for the acquisition of the engineering point of view before much real assistance can be rendered. Crises such as the present have broken down many forms of control based on inadequate knowledge of affairs to be controlled, and thus the value of the engineering aspect of industrial organization and control is being more adequately recognized. It seems, therefore, that one of the principal problems of the managerial function is to determine the basic prime variables of the industry it proposes to control and establish means by which these may be quickly and conveniently recorded and analyzed.

Under such methods the management will not be required to call in a department head and ask for a statement of affairs. This immediately makes known to the department head that the manager does not know what is really being accomplished, and his influence is accordingly lessened. If, however, these affairs are known to the management thru adequate records, it will be possible for the management to call in any particular department head and tell him that his department is *not going to show results if present conditions continue,* why it is not, and what particular things must be remedied to obtain better results and how it may be done. There is nothing so helpful to the keeping of all divisions of manufacture up to a high state of perfection as the feeling that the management really knows what is going on and can be of real help when assistance is required. When the management adopts the attitude of real helpfulness and looks upon itself as the chief servant of the industry, then we will have made a great advance toward a more adequate control of enterprises. It is the duty of the management to foresee and prevent difficulties arising, and this can only be accomplished by the establishment of adequate channels of information on the factors which condition the success of the enterprise.

It has been the experience of many to learn of well-conceived schemes of plant management falling away from the plane of perfection on which they have been established and thus discredit the value of scientific management principles. This again seems to indicate the need of an educational campaign among those who are to be depended upon to operate and keep in adjustment the new machine by which manufacture is to be controlled. No one would expect a delicately adjusted machine to operate well in the hands of an unskilled mechanic, yet many highly developed plans of management have been expected to continue in good operation in the hands of unsympathetic and poorly informed foremen. It seems that those who are capable of conceiving the broader principles of management and devising means for their embodiment in industries have gone too far beyond the capacity of those who are supposed to coöperate understandingly. In any improvement in management methods there must accordingly be promulgated a sympathy and understanding on the part of those affected thereby. It is dangerous to proceed in improvements beyond this point, for the plant will soon drop back to the level of understanding of the force and the investment will be lost.

Employers must surely take an interest in the education of their men, for no progress can be made beyond the general plane of intelligence of the shop.

This can be accomplished thru coöperation with trade schools, correspondence schools, and the industrial departments of the Y. M. C. A. No matter how excellently the scheme of management and the methods of operation may be devised, no permanent progress will be made nor results attained if the vitalizing influence is lacking. This sort of problem cannot be solved in terms of x and y, and its importance is great in proportion to its difficulty of formulation. It is the thing which holds men together and creates in them a real desire to coöperate. It prevents men from taking a secret pride in another man's downfall or failure. It makes each department head feel that he is there to serve every other department, and his success is measured in terms of real service and helpfulness. An organization without this spirit is dead and will never hold together for a long period of time. While, therefore, it is incumbent on the management to see that the best methods of operation are devised and the most reliable means of control are established, it is believed that these will never accomplish the desired result without a proper selection of personnel thru which the real life of the organization may be maintained.

It is beyond the province of this discussion to consider the details involved in the formulation of methods of procedure by means of which these problems of management may be solved in any industry, for, while each kind of industry presents the same general management problems, the means employed for their solution are very often quite different, because of the nature of the commodity dealt with and local conditions to be encountered, and therefore these details are not particularly helpful. We wish rather to realize that there is lacking in American industrial life that conception of the management function which is the foundation upon which all successful methods of factory operation must rest. When the engineer is more intimately associated with our financial interests and the university is more closely identified with productive enterprises, it is believed that the resulting amalgamation will effect a change in attitude toward the problems of management which will inaugurate the creative measures necessary. It seems there must be a closer coöperation of all interests factoring in industrial development in order that a true perspective may be had of the scientific, financial and human elements of the management problem. It is believed that this must be effected by a campaign of education which shall include the man at the bench as well as those who control his environment.

CONCRETE SHIPS*

BY L. R. FERGUSON†

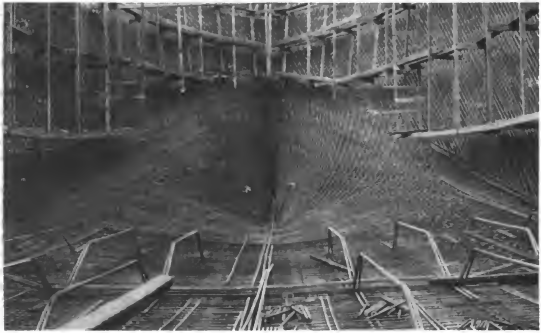
THE present situation regarding ships is acute. The published reports of the sinkings of vessels by submarines indicate that a vast tonnage has been destroyed and the mad uncivilized warfare goes on. We must meet it and beat it, and beat it we will.

When the German Government decided it would break one more of its promises and remove itself one more step from the practices of civilized people, it made the vital mistake of assuming that the United States would either allow it to proceed as it desired or else would put small hindrance in its way. It guessed wrong in this as it has guessed wrong in so many cases. Every ounce of energy and every resource we possess will be used to the utmost to win this war, and we must win it in such a conclusive way that future generations will never have the job to do over again.

In this work we have many problems to solve, and one of the biggest of these is the problem of providing sufficient ships. We are straining every effort to that end. Boats are being built as rapidly as our shipyards can turn them out, and anything which promises to help increase the tonnage is of interest to the Government. This brought up the question of constructing vessels of concrete.

I am not going into a discussion of the details of designing a concrete ship, but it will be interesting to those who have not studied the problem to consider the general assumption upon which such a design is based.

In the first place, the boat is supposed to be supported in two different ways: first, for hogging, and, second, for sagging. That is, the wave in one instance is supposed to support the ship in the center, with the ends more or less hanging out in space; and, in the second case, the ship is supported at the bow and stern on the crest of the waves, the trough of the wave being under the center of the boat. These waves are supposed to be of a height one-twentieth the length of the ship. Considering the ship as a beam, this produces alternate tensile and compressive stresses in both the top and bottom of the structure. This governs the design of the ship as a longitudinal girder.



INTERIOR VIEW AT BOW

The ship also must be designed so that the sides and bottom will resist the hydrostatic pressure, and for this a system of transverse members, called frames, is provided. The frame is our big job. The method of solution usually used is to consider the frame as a ring and use the ring formula. This corresponds to the elastic arch theory. It is far from a simple proposition to design a concrete arch by the elastic theory, and here our supports are fixed. With the concrete boat nothing is fixed, and we must go thru a long process to determine the position of the neutral axis in different parts of the frame, under the various conditions of external force which must be taken account of.

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* Paper read at meeting of the Delaware River Branch of the American Society of Marine Draftsmen, January 11, 1918, at the Engineers' Club.

† Portland Cement Association.

Around the frame is the shell. This has two functions to perform besides the primary one of keeping out the water. First, the side may be thought of somewhat as a floor slab, the load being the hydrostatic pressure which it distributes to the frames or transverse members of the boat. That is a comparatively simple proposition, for the frames can readily be spaced to produce the span we desire for this slab. In addition to this, however, the shell acts in the same way as the web of a box-plate girder.

The analogy can be carried further, for the boat frames can be considered as the stiffeners, and the deck and bottom of the boat can be thought of as the flanges. The most serious consideration in designing the shell is that of shear. I am referring to the shear of the deck, which means the difference in elevation between the bow and the deck amidships. The shear I am now referring to is the strength shear which comes near the quarter points. In this connection some interesting problems arise. For instance, do the frames or vertical stiffeners increase the shear section, and if they do, how much? Does the bending of the vertical reinforcing of the shell into the bottom and deck sufficiently anchor these rods to produce the same effect as rigid attachment to the longitudinal reinforcing? Probably the most serious condition of which account must be taken is the effect of alternate tensile and compressive stresses in the longitudinal members.

INTERIOR VIEW AT STERN

There are a number of questions to be answered, and the answering of which requires a knowledge of concrete of the highest order.

I have just touched upon some of the starting points from which the design of a concrete ship must be developed, and the further the design proceeds the more interesting the problem.

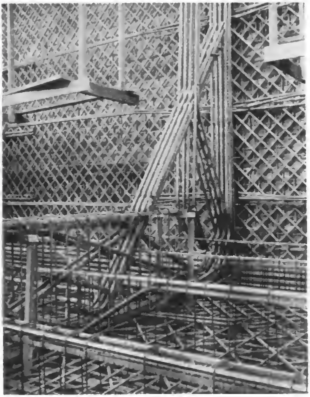
Let us now consider some of the advantages of the concrete ship, and such consideration must be governed by present conditions, altho some of them will hold after we have won this war.

The material to be used in building concrete ships is plentiful and widely distributed. It is not used for ships now being constructed, so there will be no interference with the present programs. The class of labor to be used for the concrete ship is different from that used on either the wooden or steel ship, and is mostly unskilled. Above all, the speed with which concrete ships can be built is of the utmost importance.

The maintenance cost of the concrete ship will be small, altho the idea, held by a number of engineers, that barnacles will not adhere to concrete is wrong. This, however, can probably be overcome, and, in any event, the conditions will not be any worse than on a steel ship.

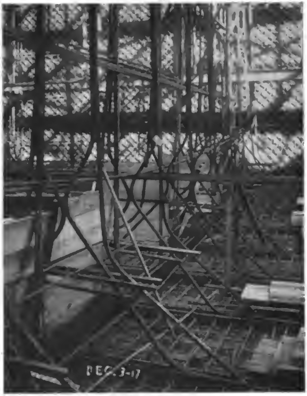
The original cost of a concrete ship will probably be considerably less than steel or even wood. Of course, the resistance of concrete to fire is an important consideration. The possibilities of securing practically any shape of bow and stern desired will probably turn out to be a great advantage. The shape of the steel and wooden ships is to a considerable extent governed by the characteristics of the material used. With concrete, however, we can make the bow and stern to conform to any conditions. Interesting developments along this line may ultimately be looked for. The steel in the concrete ship can be placed where it will be most effective, whereas in both the steel and wooden ship the efficiency of the material is often reduced considerably by the necessity of making joints.

The objections frequently raised against concrete for ship construction are that the weight of the material is too great. The same thing was said about steel when the use of that material was first advanced. As a matter of fact, the weight of the hull of a concrete ship probably will be little, if any, more than that of a wooden ship of equal dead weight carrying capacity. The disintegrating effect of salt water on the concrete is advanced as a reason for not using concrete ships. This, however, can readily be prevented by proper methods of protection. The possibility of corrosion of the steel reinforcing is a more serious consideration. The investigations of marine structures which Mr. Wig and I have been working on for some time past have brought to light the fact that there is great danger of cracking occurring in reinforced concrete which is exposed to moist sea air in cases where common methods of construction are followed. This, too, can be overcome, however, by using proper precautions.



REINFORCEMENT OF HULL

The concrete boat is not quite as new a development as most people think. The first reinforced concrete vessel was in the form of a small rowboat built in 1849 by a Frenchman named Lambot, and the boat is now in service at 68 years of age.



ARRANGEMENT OF REINFORCING RODS

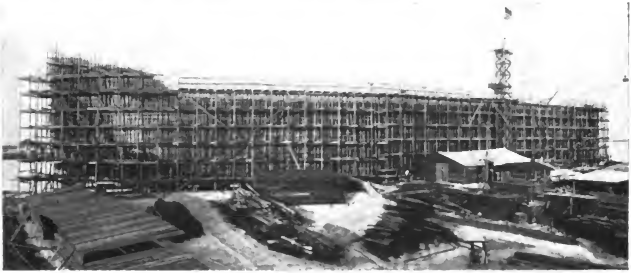
A floating chalet supported by a reinforced concrete pontoon, measuring 67 feet long by 21 feet wide, was built in Rome during the year 1897. Another interesting example built in the succeeding year was a schooner employed for some years in the North Atlantic coasting trade, the serviceability of this form of construction having been demonstrated by the fact that the vessel escaped without injury after having been driven on the rocks near Cape Charles. One of the first reinforced concrete barges in Europe was completed early in the present century from the designs of M. Hennebigue, of Paris, on the River Lozere, where it has been in continuous service for dredging purposes. The barge measures 50 feet long by 13 feet wide by 3 feet 4 inches deep, and it is recorded that the initial cost was much less than that of a timber or steel structure of the same dimensions, while the practical absence of maintenance charges has added very considerably to the ultimate economy effected.

Other barges, lighters, and pontoons followed in fairly rapid succession, the firm of Gabellini, of Rome, having been particularly enterprising in the new branch of work. By the end of 1912 they had constructed at least 20 vessels of the lighter class and over 60 pontoons for floating bridges. Included in the former category were several lighters for the Italian Government and a steam collier, these and all other vessels of the same class having been constructed with double hulls and water-tight compartments.

In Germany reinforced concrete vessels of the motor launch and barge types have been constructed, among the latter being a barge 130 feet long by 20 feet beam, said to have been built at a cost 25 per cent. less than that of a steel barge. In North and South America a good many barges and pontoons have been constructed in reinforced concrete during the last ten years. Typical examples are furnished by a barge at Ontario, 81 feet long by 24 feet beam by 7 feet deep; a fleet of lighters, 100 feet long, 30 feet beam, built at San Francisco for the coasting trade; several lighters and pontoons on the Panama Canal; and some scows 112 feet long by 28 feet beam built at Fairfield.

Recently the greatest advance in concrete ship construction has taken place in Norway, where there are at present several firms constructing concrete barges and seagoing vessels.

What the final outcome of this development of the concrete ship is going to be is an interesting question. Wars always cause many radical changes in our modes of life and in our methods of overcoming physical obstacles. Is it possible that one of the permanent gains the war is to leave us will be the concrete ship? We shall see.



5000-TON REINFORCED CONCRETE VESSEL UNDER CONSTRUCTION AT REDWOOD CITY, CAL.
(Illustration courtesy of International Marine Engineering)

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LEWIS H. KENNEY, CHAIRMAN

SPECIAL MEETING

At the Club House, Wednesday, February 6, 1918, 8.15 P. M.

The address of the evening will be made by **Dr. R. S. MacElwee,** Columbia University, on **"Port and Terminal Facilities."**

The paper will be illustrated with lantern slides.

Dr. MacElwee will discuss the fundamental principles of port development, balancing reservoirs which are required at various points for the movement of freight, general designs of piers, general designs of freight-handling facilities; the subject of waterside delivery by lighter to warehouse and industrial plants; the possibilities of upland development in port areas, and the economic advantage to be gained by linking both industries and commercial warehouses with full flexibility to all water and land carriers.

MEETING FOR JUNIOR MEMBERS

Tuesday, February 12, 1918, Meeting at the Engineers' Club

The following paper will be presented: **"Electricity as Applied to Traction." By Mr. E. M. Bredin.** An informal smoker will be held after the meeting.

REGULAR MEETING

At Witherspoon Hall, Friday, February 15, 1918, 8.15 P. M.
This will be a Joint Meeting with the Columbia University Club

The address of the evening will be made by **Prof. Douglas W. Johnson,** Professor of Physiography, Columbia University, on
"The Influence of Topography upon the Strategy of the European War."

The paper will be illustrated with colored lantern slides.

Members of Affiliated Societies are cordially invited to attend.

Members of the Club and Affiliated Societies are privileged to invite ladies.

General plans of campaign and detailed movements of armies are both profoundly affected by the topography of the country over which the contending forces must move. Professor Johnson's address will explain the topography of the western front with some fullness, and show how it determined the plan of campaign adopted by the German General Staff. The influence of terrain upon the Battle of the Marne and the Battle of Verdun will be more briefly noted. In conclusion, the Italian theatre of war will be described, and some account given of the topographic features opposing an Italian advance and favoring a Teutonic invasion.

CALENDAR OF REGULAR MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

1918

DAY OF MONTH AND WEEK — NAME OF SOCIETY

First Monday............**American Society of Civil Engineers**
April 1.

Second Monday ....**American Institute of Electrical Engineers**
February 11, March 11, April 8, May 13, June 10.

Fourth Monday..........**Philadelphia Safety Council**
February 25, March 25, April 22, May 27, June 24.

Second Tuesday ....**Engineers' Club (Junior Meeting)**
February 12, March 12, April 9.

Third Tuesday...........**Engineers' Club**
March 19, April 16, May 21, June 18.

Fourth Tuesday..........**American Society of Mechanical Engineers**
February 26, March 26, April 23, May 28, June 25.

First Wednesday.........**Technology Club**
February 6, March 6, April 3, May 1, June 5.

First Thursday...........**Worcester Tech Club**
February 7, March 7, April 4, May 2, June 6.

Second Thursday ....**American Society of Heating and Ventilating Engineers**
February 14, March 14, April 11, May 9, June 13.

Fourth Thursday.........**Society of Automotive Engineers**
February 28, March 28, April 25, May 23, June 27.

Third Friday.............**Engineers' Club (February)**
February 15.

Third Friday ....**Illuminating Engineering Society**
February 15, March 15, April 19, May 17, June 21.

Engineers' Club Meetings at Witherspoon Hall will be as follows:

Friday, February 15, **Engineers' Club** Meeting.

Members of all Affiliated Societies are invited to these meetings.

SCHEDULE OF MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

FEBRUARY, 1918

Wednesday,	**February**	**6, 1918**	Special Meeting Engineers' Club Address: "Port and Terminal Facilities" **Dr. R. S. MacElwee**	**Engineers' Club**	8.15 P.M.
Wednesday,	**February**	**6, 1918**	Technology Club of Philadelphia Informal dinner at 6.30 P.M., preceding meeting	**Engineers' Club**	8.15 P.M.
Thursday,	**February**	**7, 1918**	Worcester Tech Club Address: "Compression Rheostats" **Arthur H. Allen**	**Engineers' Club**	8.15 P.M.
Monday,	**February**	**11, 1918**	American Institute of Electrical Engineers	**Engineers' Club**	8.15 P.M.
Tuesday,	**February**	**12, 1918**	Junior Meeting Subject: "Electricity as Applied to Traction" **E. M. Bredin** An informal smoker will be held after the meeting	**Engineers' Club**	8.15 P.M.
Thursday,	**February**	**14, 1918**	American Society of Heating and Ventilating Engineers Continued Subject: "Modern Heating and Ventilating Appliances for School Buildings" **Chas. V. Haynes**	**Engineers' Club**	8.15 P.M.
Friday,	**February**	**15, 1918**	Regular Meeting Engineers' Club Address: "The Influence of Topography upon the Strategy of the European War" **Prof. Douglas W. Johnson**	**Witherspoon Hall**	8.15 P.M.
Friday,	**February**	**15, 1918**	Illuminating Engineering Society	**Engineers' Club**	8.00 P.M.
Monday,	**February**	**25, 1918**	Philadelphia Safety Council	**Engineers' Club**	8.15 P.M.
Tuesday,	**February**	**26, 1918**	American Society of Mechanical Engineers Address: "The Income Tax" **Carl Barth**	**Engineers' Club**	8.15 P.M.
Thursday,	**February**	**28, 1918**	Society of Automotive Engineers	**Engineers' Club**	8.15 P.M.

Wednesday,	**March**	**6, 1918**	Technology Club	**Engineers' Club**	8.15 P.M.
Thursday,	**March**	**7, 1918**	Worcester Tech Club	**Engineers' Club**	8.15 P.M.
Monday,	**March**	**11, 1918**	American Institute of Electrical Engineers	**Engineers' Club**	8.15 P.M.
Tuesday,	**March**	**12, 1918**	Junior Meeting	**Engineers' Club**	8.15 P.M.
Thursday,	**March**	**14, 1918**	American Society of Heating and Ventilating Engineers	**Engineers' Club**	8.15 P.M.

SECRETARY'S NOTICES

REGULAR MEETING OF THE BOARD OF DIRECTORS

JANUARY 8, 1918

The meeting was called to order at 7.15 P.M., with President Vogleson, Directors Fernald, Henderson, J. C. Wagner, Kenney, S. T. Wagner, Forstall, Bullens, R. M. Barr, Past President Swaab, Treasurer Stevens, and Secretary Stockly in attendance. Vice-Presidents Yarnall and Andrews, Directors Hayward, Moody, Ehle, G. W. Barr, and Past President Ledoux were excused. Vice-President Eglin and Past President Carter were absent.

The minutes of the Regular Meeting of the Board held December 11, 1917, were approved.

REPORT OF THE PRESIDENT

In accordance with authority granted by the Board at its December 11 meeting, the following have been appointed to constitute the special committee on Conservation of Fuel:

George R. Henderson, Chairman
S. L. Kneass
H. F. Sauville
R. H. Fernald
H. L. Moody
Emmett B. Carter
A. C. Wood

In response to an invitation received from the National Security League to appoint three delegates to the Congress of National Service to be held in Chicago, February 21 to 23, 1918, President Vogleson was authorized to appoint delegates.

REPORT OF THE SECRETARY

A communication having been received from the Secretary of the Engineering Association of New South Wales, stating that the Council of the Association extends the privileges of full membership to any members of our Club who may at any time be visiting Sydney, the Board extended similar courtesies to this Association.

The Philadelphia Safety Council has advised that representatives on the Board and committees will be appointed, in accordance with the provisions of our By-Laws, at its meeting on January 15.

In accordance with the By-Laws, Article IV, Section 7, Mr. H. P. Gant was unanimously elected to fill the vacancy in the Directors-at-large caused by the election of the Philadelphia Safety Council to affiliation, for the balance of the present fiscal year, term to expire July, 1918.

REPORT OF THE TREASURER

The report of the Treasurer, as submitted to the members of the Board, was accepted.

REPORT OF THE COMMITTEE ON HOUSE

The Committee reported that arrangements were being made for a housewarming to be held in the Club House on either February 12 or February 22, depending on the progress made this month on the new building work.

The Committee also plans to send out notices to all members, urging them to attend a special dinner which will be given coincident with the opening of the new dining-room and kitchen extensions, the dinner to be held from 7 to 9 P.M. Only members and their guests may attend the dinner, as adequate accommodations are not yet available for entertaining ladies.

REPORT OF THE COMMITTEE ON MEMBERSHIP

On recommendation of the Committee, the following were elected:

To *Active* Membership:

Carl C. Bailey	Robert C. Morgan
Stewart A. Jellett	James A. Nelson
Harry T. Jones	Robert C. Rahm
Carl Lester Kimbell	Felix J. Wasilkowski
Manly J. Miller	

To *Junior* Membership:

Robert Cleeland	Harman M. Molony
August H. Heine	Robt. L. Satterwhite, Jr.
Ellis George Joseph	George G. Urquhart
C. Russell Laverty	Raymond W. Wilkinson

REPORT OF THE COMMITTEE ON PUBLICATION

The Committee presented a report, showing an unexpended balance in its appropriation of $230.11, after deducting $500 which was transferred to the Committee on House.

REPORT OF THE COMMITTEE ON PAPERS

The Committee reported that final arrangements were completed for the next three Club meetings, on January 16, 29, and February 6, and announcement had been made in the Club JOURNAL.

REPORTS OF SPECIAL COMMITTEES

Building Committee

It was reported that, due to weather conditions, the work of alterations had been retarded during December; but, during the present month, excellent progress had been made. From present indications, the new dining-rooms and kitchen should be ready for use by Lincoln's Birthday (February 12).

Committee on Conservation of Fuel

The Committee reported they had held a meeting, and, in order to avoid a duplication of effort, information was being solicited on the subject under consideration.

The meeting adjourned at 8.45 P.M.

ABSTRACT OF MINUTES OF THE BUSINESS MEETING OF THE CLUB

HELD WEDNESDAY EVENING, JANUARY 16, 1918

The meeting was called to order at Witherspoon Hall by Vice-President Eglin at 8.15 P.M. About 1200 members and guests were in attendance.

The minutes of the meetings of December 10 and December 19, 1917, as printed in the JOURNAL, were approved.

ANNOUNCEMENTS

The Board of Directors elected, at its last meeting, the following to membership: Active, nine; Junior, eight.

The report of the Tellers on the amendment to the By-Laws is as follows:

Mr. President and Members of
The Engineers' Club of Philadelphia.

GENTLEMEN:

Your Tellers have counted the votes cast on the amendment to Article VII, Section 9, of the By-laws (providing for Life Membership), and declare that 228 legal ballots were cast, as follows:

For	*Against*
205	23

Respectfully submitted,
(Signed) GEORGE E. CROFOOT
JOHN P. MUDD
CHARLES F. PUFF, JR.
JOHN S. ELY.

The amendment was therefore declared adopted.

The address of the evening, "Alaska from an Engineer's Viewpoint," was delivered by Mr. Howard W. DuBois, member, and was profusely illustrated with colored lantern slides and motion pictures.

A unanimous vote of thanks was extended to the speaker.

The meeting adjourned at 10.10 P.M.

POSITIONS WANTED

Engineer, with over ten years' experience in conveying machinery (detail, design, and estimating), will consider change. Eastern location preferred. Apply Engineers' Club, No. 183.

Carnegie Institute Technical graduate, age 24 years, experienced in machine construction and foundry work, also some open-hearth experience, desires to locate with some steel foundry in or near Philadelphia. Apply Engineers' Club, No. 185.

Civil engineer—at present employed in work on estimates and contracts on highway construction—desires work in charge of construction, drafting, and highway work. Salary inside city, $125 per month or over; outside city, $150 per month or over. Apply Engineers' Club, No. 186.

Chief engineer or master mechanic with thoro technical and practical experience covering construction, operation, and upkeep of steel plants. Specialty metallurgical work, heating and melting furnaces, etc. Apply Engineers' Club, No. 187.

Safety engineer, with six years' thoro technical and practical experience in this capacity with large steel works. Apply Engineers' Club, No. 188.

Mechanical engineer, 38 years old, with 20 years' experience, possessing tact and initiative, with ability to plan and organize, desires position as chief engineer or assistant to same. Capable designer, familiar with present shop methods. Not afraid of responsibility. Philadelphia preferred. Apply Engineers' Club, No. 190.

POSITIONS OPEN

Designers—mechanical and civil, and construction engineers wanted. Apply Engineers' Club, No. 184-A.

FOR SALE

Transit (Sterling) manufactured by Warren-Knight Company, first-class condition; also tripod and level rod. Apply Engineers' Club, No. 3-b.

FOR RENT

Engineer absent from office most of the year wants to subrent one room or desk room of office suite in large office building—centrally located. Party can have use of the entire office for the period engineer is absent. Employs stenographer. A very attractive arrangement will be made with a responsible party. Apply Engineers' Club, No. 5-C.

Desk room for rent, 302 Westerly Building, 1627 Sansom Street, $5 per month. Use of telephone at six cents a call, and use of drawing table. Apply Engineers' Club, No. 6-c.

COMMITTEE ON MEMBERSHIP

D. ROBERT YARNALL, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before February 11 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

FRANK C. ANDERSON

1017 Real Estate Trust Building
District Manager, Asbestos Protected Metal Company.
Proposed by J. Reese Bailey, Robert R. John, and H. F. Sanville.

EDWARDS R. FISH

Care of Heine Safety Boiler Company, Phœnixville, Pa.
Vice-President and Secretary, Heine Safety Boiler Company.
Proposed by H. M. Lyman and R. H. Fernald.

LLOYD WIEGAND FITZGERALD

16 West Hinckley Avenue, Ridley Park, Pa.
Special Apprentice, Baldwin Locomotive Works.
Proposed by Richard C. Newbold, Walter C. Carson, and Coleman Sellers, Jr.

SAMUEL FRANK

1726 North Ninth Street, Philadelphia, Pa.
Member of firm of Steward & Stevens Iron Works.
Proposed by W. N. Mayhew and Alan Corson.

ROBERT LACY

Hotel Windermere, Philadelphia, Pa.
Chief Engineer, D. L. Taylor & Co., Inc.
Proposed by Henry DeHuff and C. F. Iszard.

ERNEST COLWELL LEETE

5534 Larchwood Avenue, Philadelphia, Pa.
Field Engineer on subway construction for Keystone State Construction Company.
Proposed by W. P. Parker and H. P. Gant.

CHESTER R. MISNER

117 Mulberry Street, Bristol, Pa.
Mechanical Inspector, Merchants Shipbuilding Corporation.
Proposed by Thomas H. Henkels and T. B. Preston.

LEIF E. NORBOM

237 East Johnson Street, Germantown, Philadelphia, Pa.
General Manager, Delaware River Dredging Co.
Proposed by George F. Pawling and James L. Fawley.

WILLIAM J. L. ROOP

Harwood Avenue, Kirklyn, Pa., Llanerch P. O.
General Superintendent, Delaware River Dredging Co.
Proposed by George F. Pawling and James L. Fawley.

JOHN S. ROWAN

308 North Holliday Street, Baltimore, Md.
President, The Rowan Controller Company.
Proposed by D. M. Petty and B. T. Hare.

WALTER J. SCHOPP

146 Lauriston Street, Philadelphia, Pa.
Mechanical Draftsman with Stewart A. Jellett Company.
Proposed by Stewart A. Jellett and Percival M. Sax.

FOR ELECTION TO JUNIOR MEMBERSHIP

NORMAN CHARLES BYE

7027 Torresdale Avenue, Tacony, Pa.
Cadet Engineer, Henry Disston & Sons.
Proposed by W. M. Boehm and Lewis H. Kenney.

STEWART CHARLES BARNETT

2515 North Thirty-first Street, Philadelphia, Pa.
Structural Draftsman, American Bridge Company.
Proposed by W. M. Boehm and Lewis H. Kenney.

D. CLARK CLEAVER

1416 Land Title Building, Philadelphia, Pa.
Estimating and Sales Engineer, F. J. Wilson Company.
Proposed by F. J. Wilson, George W. Baker, and H. N. Payne.

DANIEL P. OGDEN

1421 Arch Street, Philadelphia, Pa.
Assistant Engineer, Naval Aircraft Factory, Philadelphia, Pa.
Proposed by Lewis H. Kenney and Charles F. Phillips.

SAMUEL ISAIAH SACKS

3219 Fontaine Street, Philadelphia, Pa.
Draftsman, Department of City Transit.
Proposed by Wm. S. Twining, Henry H. Quimby, and Fred C. Dunlap.

L. CHEYNEY SMITH

Sunnyhill, Media, Pa.
Assistant Educational Director, Y. M. C. A.
Proposed by William Easby, Jr., and W. P. Dallett.

JUNIOR SECTION

Dr. W. M. Boehm, Chairman *Ex Officio* H. I. Goldstein, Chairman A. B. Bishop, Secretary

THE Junior Section held its second annual dinner on Tuesday evening, January 8, in the Club Library. Mr. W. W. Pickles, chairman of the Entertainment Committee, presided. About thirty-five members and guests were present. Mr. Joseph A. Steinmetz, president of the Aero Club, and Mr. J. A. Vogleson, our own president, were guests of honor.

Mr. Steinmetz's remarks following the dinner were replete with interesting personal experiences and striking facts. In summing up the obligations of our technical young men in time of war, he emphasized the crying need for skilled workers in aircraft manufacturing; also for technical men for deck and engine-room officers of our growing merchant marine. He showed the great opportunities for service to our nation, accruing at the same time to our own advancement as future engineers in every field of technical endeavor. Further, he dwelt upon the desirability of establishing a collection of arms, munitions, and all kinds of devices pertaining to the war, as a museum for our Club, and especially asked the Juniors' help in making this plan a reality. Such a museum would have great historical, sentimental, and educational value for future generations of engineers.

An interesting feature of the evening was the reading of letters acknowledging our Christmas gifts to those in the service of our country. Messrs. E. W. Barker, T. H. Doyle, J. M. Spillan, W. D. Faust, E. A. Millar, and W. P. Honwen answered. Undoubtedly, the Christmas tokens had brought the desired cheer to our comrades. The letters will be filed with the Secretary of the Section, who will keep a war record, in accordance with a resolution adopted by the meeting.

President Vogleson, for the Senior body, gave utterance to the Club's appreciation of the Juniors' virile and successful activities. Other short addresses were made by Doctor Boehm and Messrs. Goldstein and de Macedo.

Much to the regret of all, Mr. Pickles was compelled to resign the chairmanship of the Entertainment Committee, owing to the fact of his entering the sanitation service of the Government. A rising vote of thanks was tendered him for his valuable services to the Section. Mr. E. M. Bredin has been appointed his successor, and will also take Mr. Pickles's place on the Executive Committee.

At the February meeting, on the 12th, the following paper will be read by Mr. E. M. Bredin: "Electricity as Applied to Traction." An informal smoker will follow. All Juniors and their friends are cordially invited.

Extracts from Letters from Members in the Service

A member from Camp Hancock writes:

"Your box of smokes arrived before Christmas, and I want to thank you for them and tell you how much it was appreciated. It is lonesome in camp on a holiday, but the fact your friends at home have thought of you helps a lot."

Another from Camp Hancock:

"We did not receive all the boxes until the day before New Year's, so they were given to the boys on New Year's Day. Will you thank all the members of the Engineers' Club for the very generous packages which they sent?"

A Junior from the same camp writes:

"I want to thank the Junior Section for the kind thought and recollection prompting the sending of the 'smokes' to brighten this Christmas, spent far away from friends and associates, and in the face of so many difficulties."

Another:

"I appreciate the greetings and the 'smokes' sent by the Junior members. They gave much enjoyment and pleasure, and it makes one feel mighty good to know that he has friends back home who are right behind him in everything he does to help bring victory to our cause."

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, Chairman

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF JANUARY 20, 1918

NAME	RANK	CORPS	LOCATION
Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Chattanooga, Tenn.
Anders, D. W.	Captain	Company D, 502nd Engineers	Overseas Service
Andrews, J. H. M.	Major	Engineers, N. G. U. S.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
Asplundth, E. T.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Atterbury, W. W.	Brigadier-General	Director-General of Railways	France
Barker, E. W., Jr.		Truck 4-304 Ammunition Train	Camp Meade, Admiral, Md.
Bassett, F. H., Jr.		Officers' Training School	Camp Meade, Md.
Bear, H. K.	Private	Gas Defense Service	Washington, D. C.
Bell, Frank F.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
Betus, A. J.		111th Infantry	Camp Hancock, Augusta, Ga.
Biester, W. H., Jr.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Booz, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	France
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. F.	1st Lieutenant	U. S. Naval Reserve Senior Engineer Officer	U. S. S. "Jupiter"
Boyd, G.	1st Sergeant	Overseas Repair Section No. 1	Gas Defense Service, Medical Corps
Bradford, J. S.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Bransome, E. D.		Mass. Inst. Technology Aviation Camp	Boston, Mass.
Bream, C. C.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Breen, J. W.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, France
Brewer, P. C., Jr.	Lieutenant	307th Engineers	Camp Wheeler, Macon, Ga.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Broadhead, Alex.		19th Reserve Engineers	American Expeditionary Forces, France
Broderick, D. F.	Major	Ordnance Officers' Reserve Corps	Rock Island Arsenal, Rockland, Ill.
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, France
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. F.	Lieutenant	Engineer Officers' Reserve Corps	Camp Lee, Petersburg, Va.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.		Carriage Division, F. A. Section	Washington, D. C.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Chance, T. M.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Childs, H. P.		7th Infantry, Reserve Officers' Training Camp	Ft. Myer, Va.
Colgan, R. J.	Captain	American Expeditionary Forces	Care of Adjutant-Gen'l, Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	Camp Hancock, Augusta, Ga.
Crowther, E. C.	Corporal	Jefferson Hospital Unit	
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Albemarle Bldg., New York
Cutler, James B.		Reserve Officers' Training Camp	Fort Oglethorpe, Chattanooga, Tenn.
Derby, C. F.	Captain	Ordnance Officers' Reserve Corps	Camp Lee, Petersburg, Va.
Dill, C. M.		Company K, 319th Infantry	Camp Lee, Petersburg, Va.
Donnelly, J. B.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Doyle, T. H.	2nd Lieutenant	Quartermaster Officers' Reserve	Camp Meade, Md.
Dunn, M. L.	Ensign	Reserve Officers' Quarters	U. S. Naval Academy, Annapolis, Md.
Dyson, C. W.	Rear Admiral	Bureau of Steam Engineering, U. S. N.	Washington, D. C.
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.
Elcock, Chas.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Farr, Roy S.	2nd Lieutenant	301st Engineers' Train	Camp Devens, Ayer, Mass.
Faust, W. D.		103rd Engineers	Camp Hancock, Augusta, Ga.
Fenton, Powell		Aviation Corps	France
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	Philadelphia Navy Yard

Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	Laurel, Md.
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	Washington, D. C.
Gauthier, Jordan	2nd Lieutenant	56th Engineers	Washington, D. C.
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American University, Washington, D. C.
Getz, Ralph F.		19th Reserve Engineers	American Expeditionary Forces, France
Gillan, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Gilpin, F. H.	Inspector of Ordnance	Research Laboratory, Picatinny Arsenal	Dover, N. J.
Gracey, A. L.	Private	Ordnance Officers' Reserve	Watervliet Arsenal
Gravell, W. H.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, France
Gribbel, W. G.	Captain	30th Engineers	Overseas Service
Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C.
Grossman, P. R.	Private	447th Depot Detachment Engineers	Camp Devens, Ayer, Mass.
Gwilliam, Mark R. M.	1st Lieutenant	21st U. S. Infantry	San Diego, California
Hall, W. A.	Lieutenant	Naval Coast Defense	Philadelphia Navy Yard
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	105th Engineers	Camp Sevier, Greenville, S. C.
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hathaway, H. K.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
Heger, J.	Lieutenant	Engineers' Depot	Washington, D. C.
Henry, J. C.		Headquarters Dep't 19th Reserve Engineers	American Expeditionary Forces, France
Hetherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Infantry	Charlotte, Ga.
Hollenback, E. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.	1st Lieutenant	Dental Corps, 28th Division	Camp Hancock, Augusta, Ga.
Houwen, W. P.		Section Headquarters, United States Navy	Lewes, Delaware
Hulme, Norman	1st Lieutenant	458th Truck Co.	Fort Myer, Va.
Jones, Jonathan	Captain	23rd Regiment Engineers	Camp Meade, Md.
Kennedy, J. H.		Aviation Section, Signal Corps	American Expeditionary Forces, France
Kern, F. X.	Lieutenant	23rd Regiment Engineers	Camp Meade, Md.
Kneass, E.	Ensign	U. S. Naval Academy	Annapolis, Md.
Knight, C. C., Jr.	Lieutenant	81st Division, Field Artillery	Camp Jackson, S. C.
Koelle, W. F. B.	Sergeant	Signal Corps	Washington, D. C.
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	American Expeditionary Forces, France
Lawrence, G. E.	Lieutenant J. G.	Naval Coast Defense	Philadelphia Navy Yard
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Levin, J.		2nd Officers' Training Camp	Fortress Monroe, Va.
Lynch, N. L.		Engineer Officers' Reserve Corps	Washington Barracks, Washington, D. C.
MacGarrigle, G. L.	Private	Company "B," 103rd Engineers	Camp Hancock, Augusta, Ga.
Magee, J. W.	2nd Lieutenant	504th Engineers' Corps	Washington Barracks, D. C.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Martin, T. S., 3rd	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Mayburry, W. G., Jr.	Lieutenant	334th Field Artillery, National Army	Camp Pike, Ark.
McCausland, J. R.	Master Engineer	446th Engineers, Depot Detachment	Camp Devens, Ayer, Mass.
McClintock, J. L.		U. S. Navy Radio Service	Parkway Bldg. *pro tem.*
McCord, J. B.	Lieutenant-Colonel	Ordnance Officers' Reserve	War Department, Washington, D. C.
McCoy, J. F.		Aviation Section, Signal Corps	Princeton, N. J.
McGarrigle, J. J.		2nd Officers' Training Camp	Fortress Monroe, Va.
McMillan, H. L.	Major	Engineer Officers' Reserve Corps	Camp Dix, Wrightstown, N. J.
Millar, E. A., Jr.	1st Lieutenant	Ordnance Officers' Reserve	Camp Hancock, Augusta, Ga.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Chattanooga, Tenn.
Moon, T. E.	Private	Ordnance Department	Augusta Arsenal, Augusta, Ga.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Myers, W. C.	Captain	Ordnance Officers' Reserve	Washington, D. C.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	Captain	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixon-Miller, M.	Captain	Company "B," 501st Engineers	Camp Merritt, N. J.
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
Oakes, J. C.	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Otwell, Curtis W.	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Perry, Edward		Quartermaster Officers' Reserve	Camp Lee, Petersburg, Va.
Peterman, J. M.	Private		Camp Meade, Admiral, Md.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	

Prichett, F. B.		First Troop, Phila. City Cavalry	Camp Hancock, Augusta, Ga.
Prince, H. W.		Squadron 80	Camp Eimerman, Fort Worth, Texas
Pugh, M. R.	Major		American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	19th Reserve Engineers	American Expeditionary Forces, France
Reed, Thomas	Captain	Ordnance Officers' Reserve Corps	Office of Inspector of Ordnance, U. S. A., Plainfield, N. J.
Reninger, H. A.	Major & Adjutant, A. G. Dept.	53rd Depot Brigade	Camp Hancock, Augusta, Ga.
Ridge, R. S.	Sergeant	23rd Engineers	Camp Meade, Admiral, Md.
Ridgway, J. J.	1st Lieutenant	Co. P, 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.		Electrical Research Dept., Aviation Section, Signal Corps	Mineola, L. I.
Roop, J. C.	Captain	17th Engineers	France
Roth, F. E.	Private	316th Infantry	Camp Meade, Admiral, Md.
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	Washington, D. C.
Schmidt, A. H.		Company "C," 315th Infantry	Camp Meade, Admiral, Md.
Schoch, J. B.	Lieutenant	109th U. S. Infantry	Camp Hancock, Augusta, Ga.
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Sheahan, J. C.	2nd Lieutenant	Co. 11, Section B, Bldg. 6	Camp Jos. E. Johnston, Jacksonville, Fla.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Smith, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	Overseas Service
Spencer, Alex. G.		Royal Flying Corps	Toronto, Canada
Spillan, J. J. D.	Sergeant	Hq. 53, Brig. F. A.	Camp Hancock, Augusta, Ga.
St. John, Everett	1st Lieutenant	Coast Artillery Reserve Corps	Fort du Pont, Delaware
Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	1st Lieutenant	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
Thacher, C. H.	2nd Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
Thomas, R. S.	Lieutenant Colonel	312th Engineers	Camp Pike, Little Rock, Ark.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. Maine
Uhler, W. D.	Major	Quartermaster Officers' Reserve Corps	
Vaughan, D. L.	1st Lieutenant	Officers' Reserve Corps	Camp Joseph E. Johnston, Jacksonville, Fla.
Vogleson, J. A.	Major	Sanitary Corps	Fort Oglethorpe, Chattanooga, Tenn.
Ward, R. C.	Captain	Coast Artillery	Fort Greble, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	Camp Grant, Rockford, Illinois
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	Engineer Officers' Reserve Corps	France
Wentz, E. M.	Asst. Paymaster	Receiving Ship	Brooklyn Navy Yard
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	Camp Hancock, Augusta, Ga.
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C.	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	C. A. C. School D	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Camp Wheeler, Macon, Ga.
Zeckwer, J. A.	Ensign	U. S. Naval Reserve Force	Boarding Officer, Port of Philadelphia
Zinn, George A	Colonel	District Engineers' Office, Custom House	Portland, Oregon

REQUEST FOR INFORMATION

THE COMMITTEE REQUESTS THAT THE MEMBERS OF THE CLUB INFORM THE COMMITTEE OF THEIR ADMISSION TO THE MILITARY OR NAVAL SERVICE.

THE COMMITTEE WOULD ALSO BE PLEASED TO RECEIVE SUGGESTIONS FROM MEMBERS WHO HAVE ENTERED THE SERVICE. PLEASE ADDRESS COMMUNICATIONS TO THE COMMITTEE ON NATIONAL SERVICE.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

EASTERN PENNSYLVANIA CHAPTER

George W. Barr, President
George Boon, Secretary

THE regular monthly meeting was held Thursday evening, January 10, with Mr. H. P. Gant acting as chairman. It was announced that Mr. W. H. Timm was to present a paper on "The Modern Dairy," but, as quite a few of the members were attending a very important committee meeting on fuel conservation, it was decided to postpone this subject to a future date.

The president of the parent body, Mr. J. Irvine Lyle, paid us an unexpected visit and gave us the subjects to be discussed at the annual meeting in New York. These were as follows:

"What We Do and Don't Know About Heating," by John R. Allen; "High Temperature Drying," by B. S. Harrison; "The Temperature of Evaporation," by W. H. Carrier; "Economy in Fuel"; "Fuel Conservation"; Discussion of problems of limitation of fuel consumption in the United States; general discussion of reports of Committee on Code for Testing Low-pressure Heating Boilers; "The Engineering of Warm Air Furnace Heating," by M. Wm. Ehrlich; "Answering Fuel Needs with a New Gas Heating System," by G. S. Barrows; "Dust: Its Universality, Elimination and Conservation," by E. R. Knowles; "The Preservation of Hot-water Supply Pipe," by F. N. Speller and R. G. Knowland; "The Relation of Hot-water Service Heating to Various Types of Buildings," by H. L. Alt; "Calculations and Analysis of a Compound Gravity Low-pressure Hot-water System," by A. J. Welle; "Measurements of Low-pressure Steam Used for Heating the Buildings of the University of Michigan," by J. E. Emswider.

The Meetings Committee announces Mr. Chas. V. Haynes as the evening speaker for the meeting to be held on Thursday, February 14. His subject will be a continuance of his paper presented December 13, 1917.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ∴ PHILADELPHIA SECTION

Nathan Hayward, Chairman
H. Mouradian, Secretary, 1631 Arch Street

THERE will be two meetings of the Philadelphia Section in February, one a joint meeting with The Franklin Institute, February 7, at which Dr. Edwin F. Northrup will present a paper on "The Application of Oscillatory Currents to Heating and Electric Furnace Practice," and the other on February 11, at the Engineers' Club, which will be the Annual Students' Night.

The paper of the evening will be presented by Mr. J. S. Francis, Engineer of Appraisals for The Bell Telephone Company of Pennsylvania.

The January meeting of the Philadelphia Section of the A. I. E. E., postponed from January 14, was held January 28. The speakers were Mr. Paul Spencer, Electrical Engineer for the U. G. I. Company, Philadelphia, and Mr. G. E. Wendle, Chief Engineer of the Lycoming-Edison Company, Williamsport, Pa.

The meeting was devoted to a discussion of the fundamental principles underlying the writing of the "Specifications Covering the Construction at Crossings of Overhead Lines of Public Utilities." Mr. Spencer was Chairman and Mr. Wendle a member of the committee appointed by the Pennsylvania State Public Service Commission to prepare the specifications.

Mr. Spencer stated that, in preparing the specifications, standard usages and construction methods and specifications of various public service companies in the State, as well as the work of the Bureau of Standards and large wire-using companies in other states, had been used very extensively in arriving at basic principles and practices to be written into the specifications. He stated, also, that a large amount of original investigation and mathematical computation had been undertaken in connection with the matter.

It was pointed out that, owing to the general practice of considering a line carrying 5,000 volts or over a high voltage line, the committee had adopted this classification, and a greater factor of safety in the mechanical construction of such high voltage lines was required than for low voltage lines; the ratio of these factors being four to one. The maximum conditions upon which the mechanical design is based are zero weather, one-half inch of ice on the wires and structure, and a seventy-mile wind at right angles to the line. For low voltage lines, a wind pressure one-half as great was assumed.

Discussion brought out the thought that the actual factor of safety was much greater than assumed because of the small liability of all three of the conditions imposed occurring at the same time.

Mr. Wendle was responsible for a large part of the mathematical work involved and discussed the mathematics of catenaries and methods developed for the rapid

(Continued on Page 107)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS .·. PHILADELPHIA SECTION

LEWIS F. MOODY, Chairman. JOHN P. MUDD, Secretary, Midvale Steel Company, Nicetown, Pa.

THE FEBRUARY MEETING

THE next meeting of the Section will be held at the Engineers' Club on Tuesday, February 26, at 8:15 P.M. Mr. Carl Barth, Consulting Engineer, will give an address on the Income Tax. The paper will show the benefit of the analysis made in "engineering fashion." He anticipates at a later date to give "Supplement to Taylor's Art of Cutting Metals."

THE JANUARY MEETING

A very interesting and well-attended meeting was held at the Club on the evening of January 22. Prof. William L. Cathcart, U.S.N. (retired), spoke on "The War on Land or Sea."

The paper was profusely illustrated with excellent lantern slides.

It will be published in full in a subsequent issue of this JOURNAL.

WORCESTER TECH CLUB

GEORGE A. DENNY, Chairman ROBERT M. BARR, Secretary, Land Title Building

THE next regular meeting will be held in the auditorium of the Engineers' Club, Thursday evening, February 7, at 8:15 o'clock. Mr. Arthur H. Allen, M.E., Manager, Triumph Electric Company, will present an illustrated address on "Compression Rheostats."

Mr. Ambrose G. Warren, E.E., General Superintendent of J. W. Paxson Company, addressed the December 6 Tech meeting on "Modern Foundry Machinery." This up-to-the-minute paper brought forth a lengthy and lively discussion.

The meeting of January 3 was especially interesting. Mr. Alfred D. Flinn, Deputy Chief Engineer, Board of Water Supply, New York City, presented an illustrated address on "New York Catskill Mountain Water Supply." The paper will appear in its entirety in the March issue.

TECHNOLOGY CLUB OF PHILADELPHIA

H. A. TERRELL, President. N. A. WHITE, Secretary, Wenonah, N. J.

THE next meeting of the Technology Club will be held on Wednesday evening, February 6, 1918. There will be an informal dinner at 6.30 P.M. and the meeting at 8.15 P.M. Announcements of the speaker for the next meeting will be mailed to the members.

At the January meeting of the Club the reunion of the Technology Clubs Associated was discussed by the members present. It was the unanimous opinion that it would be unwise to hold the reunion with the present hotel and transportation facilities, and that war conditions did not warrant the expenditure of time and money in connection with the reunion at the present time. The club has communicated with the Institute authorities at Cambridge, and it is believed that the reunion will be postponed.

Major J. H. M. Andrews, of the 103d Engineers, spoke to the Club relative to the need of trained technical men in the Ordnance Corps of the Army.

PHILADELPHIA SAFETY COUNCIL

LOCAL SECTION No. 7 OF NATIONAL SAFETY COUNCIL

J. F. Conner, President

J. P. Mudd, Secretary-Treasurer,
The Midvale Steel Co., P. O. Box 1322

MINUTES OF THE PHILADELPHIA SAFETY COUNCIL'S MEETING

A MEETING of The Philadelphia Safety Council was held in The Engineers' Club on January 15, at 8.30 P.M., Mr. J. F. Conner presiding.

The report of the Nominating Committee was read. The following officers were elected:

For President—J. F. Conner.
For Vice-President—Coleman Sellers, Jr.
For Secretary-Treasurer—John P. Mudd.

The financial report for the calendar year of 1917 was read and adopted.

A committee, consisting of Messrs. R. B. Duncan and C. L. McAllester, was appointed to audit the treasurer's books.

The following men were appointed to represent The Philadelphia Safety Council with The Engineers' Club:

On the Board of Directors—J. B. Douglas.
Committee on Meetings—C. C. Black.
Public Relations—H. W. Forster.
ENGINEERS' CLUB JOURNAL—A. C. Christie.

The following committees were appointed:

Publicity Committee

Fred W. Johnson (chairman)
  Care of Philadelphia Rapid Transit Company,
  Eighth and Dauphin Streets, Philadelphia, Pa.
William L. McLean
H. P. Weaver

Program Committee

C. C. Black (chairman)
  Care of Department of Labor and Industry,
  904 Finance Building, Philadelphia, Pa.
R. B. Duncan
L. J. Freund

Membership Committee

Donald N. Frazier (chairman)
  Care of American Mutual Liability Insurance Company,
  Commercial Trust Building, Philadelphia, Pa.
J. Brogden
N. P. Lloyd
William Harmer
Henry C. Essling

Attendance Committee (special)

C. Howard Williams (chairman)
  Care of American Pulley Company,
  No. 4200 Wissahickon Avenue, Philadelphia, Pa.
Charles Lobs
C. L. McAllester
J. C. Spicer
Laura M. Roadefer
M. McGinnis

W. P. Weaver directed a round-table discussion on the subject of "Fire Prevention." A vote of thanks was extended to him for his excellent talk on the subject.

The meeting adjourned at 10 P.M.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

(*Continued from Page 105*)

calculation of the mass of data prepared for the tables and curves in the appendices to the specifications. He pointed out certain errors in Taylor's formulæ when applied to catenaries of large vertical height and showed that Pendar's formula for the parabola fitted the conditions desired in the specifications with an accuracy of three or four per cent. Mr. Wendle disclaimed any originality for any of the mathematical formulæ of the catenary, referring to the fact that most of the early text books contained all the caternary formulæ.

Mr. H. S. Warren, of the American Telephone and Telegraph Company, New York; Dr. M. G. Lloyd and Mr. W. J. Canada, of the Bureau of Standards, Washington, D. C.; Mr. Thomas Sproule, Assistant Engineer, Philadelphia Electric Company; Mr. J. L. Kilpatrick, Engineer, and Mr. J. S. Francis, Engineer of Appraisals, of The Bell Telephone Company of Pennsylvania, discussed the papers.

Among the points brought out in the discussions, one of the more important was the advantages gained in the preparation of the specifications in bringing together representatives of the various wire-using companies of the State, and advancing coöperation by a more intimate knowledge of each other's problems.

Mr. Canada spoke of the value which the preparation of the Crossing Specifications had been to the Bureau of Standards in the preparation of the Safety Code, and of the close association of the work of the Bureau of Standards and the Crossing Specifications Committee during the progress of the work.

Pago

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-3 MARCH, 1918 NO. 160

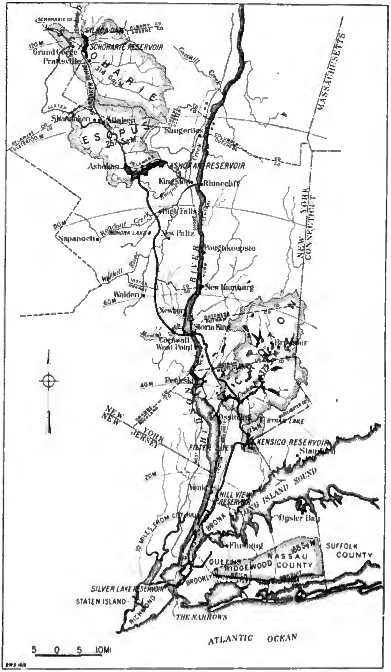
NEW YORK CITY'S CATSKILL MOUNTAIN WATER SUPPLY*

BY ALFRED D. FLINN
Deputy Chief Engineer
BOARD OF WATER SUPPLY, NEW YORK CITY

UNTIL Catskill Mountain water became available, supplies for Manhattan and Bronx boroughs were obtained principally from the Croton River, first put into use in 1842; for Brooklyn, from wells and ponds in Nassau County, Long Island, and for Queens and Richmond boroughs, from local wells mostly owned and operated by private water companies. Due to occupation of water-gathering grounds by growing communities, some smaller sources of supply became unsatisfactory. Existing systems have been outgrown, altho the more important ones will be used permanently.

Of recent years New York City's population has been increasing at the rate of about 157,000 persons each year—the equivalent of Atlanta, Hartford, or New Haven; or every three years as many people as there are in Buffalo; in four years enough persons to populate the state of Rhode Island. For each additional person approximately 100 gallons more water are required each day. Consequently, from time to time, extensive additions to the city's water supplies have been, and will continue to be, necessary. The Catskill system, the first and most important portion of which has recently been put into service, is the greatest addition ever made to any city's water resources. The second portion of this Catskill scheme, to be completed in about seven or eight years, will add an equal quantity of water. At a somewhat more distant future, if the city continues to grow, other supplies must be sought and developed.

Assuming that sufficient reasons have been advanced for additional supply of water, attention is invited to the new Catskill Mountain system constructed by the Board of Water Supply—to its sources, to works for collecting water and conducting it to the city, and incidentally to some of the engineering problems. Description of the works will be prefaced by a



MAP OF THE CATSKILL MOUNTAIN WATER SYSTEM, SHOWING ITS RELATION TO THE CROTON AND RIDGEWOOD SYSTEMS

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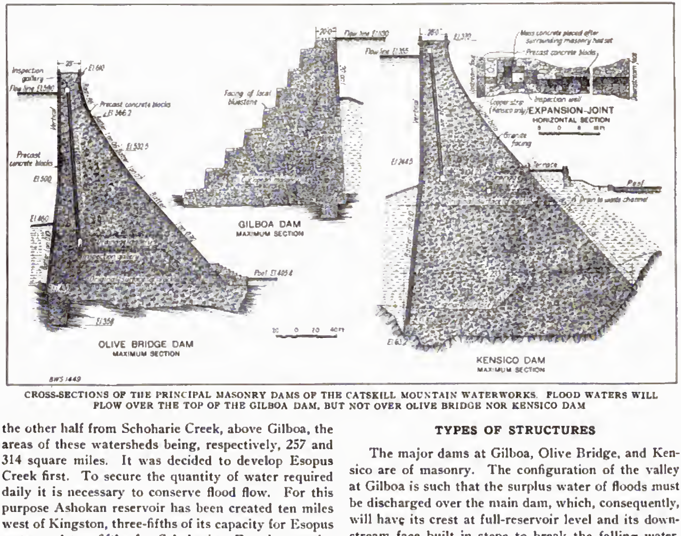
* Presented before the Worcester Tech Club, at the Engineers' Club, January 3, 1918.

BRIEF OUTLINE OF THE SYSTEM

For legal and engineering reasons, streams west of the Hudson River, in the Catskill Mountains, were chosen as the most available, economical, and best sources. It was determined that the new system should furnish as a year-in-and-year-out average 500,000,000 gallons of water daily. As a matter of engineering judgment, an aqueduct of this capacity was deemed as large as could be built in the region to be traversed, and no less an increment should be made to the city's water resources. This quantity of water, flowing thru a fifty-foot wide street at a velocity equivalent to an average walking speed, would make a stream shoulder deep. It was found that half the desired quantity could be procured from Esopus Creek, above Olive Bridge, and the other half from Schoharie Creek, above Gilboa, the areas of these watersheds being, respectively, 257 and 314 square miles. It was decided to develop Esopus Creek first. To secure the quantity of water required daily it is necessary to conserve flood flow. For this purpose Ashokan reservoir has been created ten miles west of Kingston, three-fifths of its capacity for Esopus water and two-fifths for Schoharie. For the remaining storage needed for Schoharie Creek a reservoir is to be constructed in the immediate future. From this reservoir, Shandaken tunnel, 18 miles long, 11 feet 6 inches high, and 10 feet 3 inches wide inside, of 650,000,000 gallons daily capacity, piercing the intervening mountains, will convey the water into Esopus Creek, eleven miles above the western extremity of Ashokan reservoir.

Catskill aqueduct begins at Ashokan reservoir and extends 120 miles to Staten Island, a three-day journey for the water, crossing the Hudson 3½ miles above West Point and having a branch, seven miles long, from the heart of Brooklyn to Queens Borough. With so long an aqueduct it is necessary to maintain a large store of water near the city. A natural basin was found at Valhalla, three miles above White Plains, and here Kensico reservoir has been created for this purpose. To equalize the constantly fluctuating demands against the steady flow in the aqueduct, a small reservoir was needed on ground of sufficient elevation close to the city. In Yonkers, just north of the city line, a suitable hill was discovered, and on its top Hill View reservoir has been constructed. Fifth and last is a small terminal reservoir on Staten Island, known as Silver Lake.

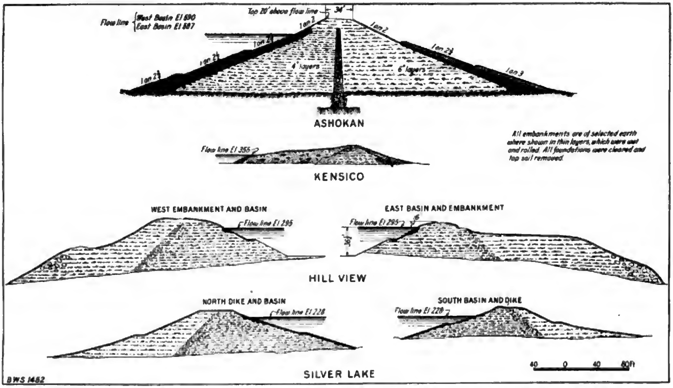


CROSS-SECTIONS OF THE PRINCIPAL MASONRY DAMS OF THE CATSKILL MOUNTAIN WATERWORKS. FLOOD WATERS WILL FLOW OVER THE TOP OF THE GILBOA DAM, BUT NOT OVER OLIVE BRIDGE NOR KENSICO DAM

TYPES OF STRUCTURES

The major dams at Gilboa, Olive Bridge, and Kensico are of masonry. The configuration of the valley at Gilboa is such that the surplus water of floods must be discharged over the main dam, which, consequently, will have its crest at full-reservoir level and its downstream face built in steps to break the falling water. Because at Ashokan floods can be more conveniently cared for otherwise, and at Kensico the reservoir can be completely controlled by manipulation of the flow from the aqueduct, no water will pass over the main dams. Each carries a highway. Olive Bridge dam is 23 feet thick at its thinnest part; Kensico, 28 feet. The former has a maximum height of 240 feet and the latter 307 feet, with maximum thicknesses at the bottom, respectively, 190 and 235 feet.

At Ashokan, to extend the main masonry dam and to fill natural gaps in the sides of the reservoir, about five miles of earth dams, or dikes, were required, attaining a maximum height of 120 feet. These were built of selected fine earth in thin layers, thoroly compacted by rolling, and have substantial core-walls of concrete, founded in rock or very impervious hardpan. These dikes are covered with grass on their tops and downstream slopes and with stone riprap and paving on the water slopes. Kensico reservoir required but a minor dike, made of liberal dimensions to utilize earth from excavations for other structures. At Hill View and Silver Lake large quantities of earth from the basins had to be disposed of, and the embankments were made of generous cross-section, only a portion being of selected earth in thin layers. At the last three reservoirs the dikes were shaped partially to resemble natural hills, and, because of great thickness, have no core-walls.



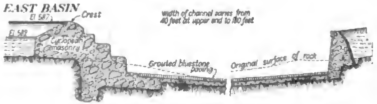
All embankments are of selected earth where shown in thin layers, which were wet and rolled. All foundations were cleared and top soil removed.

CROSS-SECTIONS OF EARTH DAMS, OR DIKES, OF THE VARIOUS CATSKILL MOUNTAIN WATER SUPPLY RESERVOIRS

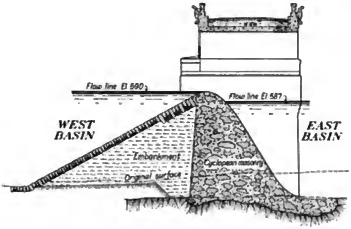
To dispose of floods occurring when Ashokan reservoir is full, a concrete waste weir, 1000 feet long, and a paved channel were constructed at a place whence the water could be safely conducted into Esopus Creek, three miles downstream from the main dam. For many reasons connected with the control of the reservoir, it was desirable to divide this great artificial lake into two basins. By extending a weir and dike from a hill jutting into the north side of the valley to the Beaverkill dikes, closing a long gap in the south side, this was readily accomplished. Opportunity was thus afforded to carry a highway across the reservoir by building a bridge on the dividing weir. For Kensico reservoir a waste weir only 50 feet long was provided, more as a concession to sentiment than to meet any real need.

Catskill aqueduct traverses a much diversified country. There are gentle hillsides and broad plains at suitable elevations along which cut-and-cover aqueducts could be constructed, in which the water flows without being under pressure; but there are hills and mountains which had to be pierced with grade tunnels, so-called, at the flowing level of the aqueduct. Many valleys, some of them wide and deep, had to be crossed. For fourteen minor valleys, riveted steel pipes were adopted, some 9 feet and others 11 feet in diameter. In each valley three pipes will be required for the full capacity of the aqueduct, altho but one has yet been laid. For protection from rusting and to make the smoothest possible interiors by covering the rivet heads and the laps of the steel plates, these pipes were jacketed with concrete and lined with Portland cement mortar. At each side of each valley a chamber containing sluice gates connects the pipes with the adjoining aqueduct.

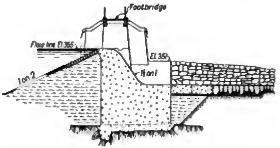
Few engineering problems required more thoro and protracted study, more boldness of design and execution, and more ingenuity than the crossings of the Rondout, Wallkill, Hudson, and Croton valleys. For economy, permanence, and security, it was decided to use circular tunnels in the rock. As the gorges originally occupied by the streams are far below their present channels, these tunnels were forced to great depths, in order to keep in rock. In them the water is under high pressure; therefore they were named pressure tunnels. For 2½ miles north of Hill View reservoir, also, the aqueduct is of this type and known as the Yonkers pressure tunnel. The largest pressure tunnel is 16 feet 7



ASHOKAN WASTE WEIR AND SPILLWAY
Crest length 990ft.

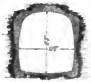


ASHOKAN DIVIDING WEIR AND BRIDGE
Crest length 1000ft

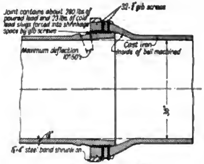


KENSICO WASTE WEIR
Maximum section
Crest length 50ft

BWS 1451

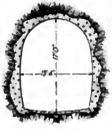


SHANDAKEN TUNNEL

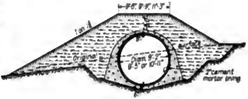

Joint contains about 280 lbs of poured lead and 73 lbs of cold lead slugs forced into shrinkage space by gib screws
32-1" gib screws
Maximum deflection 10° 50'
Cast iron
Inside of bell machined
36"
1"
6×6" steel band shrunk on

FLEXIBLE-JOINTED PIPE
NARROWS SIPHON

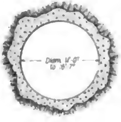
For City conduits of Catskill aqueduct standard bell-and-spigot cast-iron pipes and lock-bar and riveted steel pipes were used



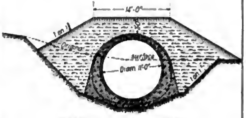
GRADE TUNNEL
(Kensico Reservoir to Hill View Reservoir, 17' 6" × 13' 9")



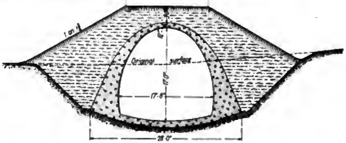
STEEL PIPE SIPHON
(Three pipes for each siphon)



PRESSURE TUNNEL
Rondout, Wa.Vall 14' 6"
Moodna 14' 7"
Hudson, Breakneck Croton Lake 14' 0"
Yonkers 16' 7"
City 15' 0" to 12' 0", 11' 0"



REINFORCED CONCRETE AQUEDUCT
KENSICO BY-PASS

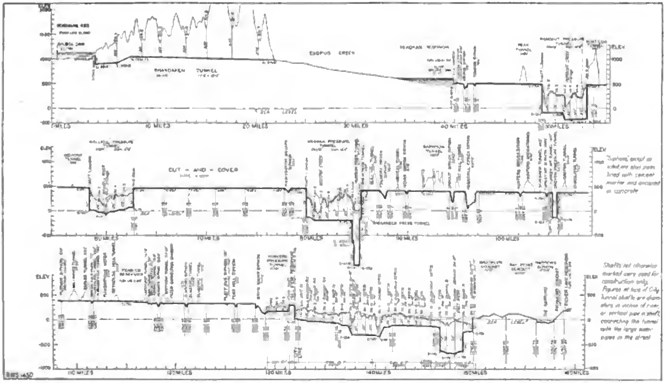


CUT-AND-COVER AQUEDUCT
(Kensico Reservoir to Hill View Reservoir, 17' 6" × 18' 0")

BWS 1450

inches and the smallest 11 feet in diameter. They are lined with concrete to improve their hydraulic properties and aid in rendering the surrounding rock more watertight by means of grouting; that is, injecting thin mixtures of cement and water into the crevices under high pressure. Each pressure tunnel has a downtake shaft at one end and an uptake shaft at the other. For the longer tunnels several intermediate shafts were required to expedite construction, which were sealed at completion of the work. Provision was made for unwatering whenever it should become necessary to enter a tunnel for inspection, cleaning, or repairs. For this purpose there is a drainage shaft, in which can be placed special pumping apparatus in a cylindrical boat or float. The drainage shaft is 75 feet from the tunnel, but connected by a drift, flow thru which is prevented, when the tunnel is in service, by a special valve. Each drainage shaft has a superstructure, of the type shown in the illustration. Exceptions became necessary at Hudson River and Croton Lake, where waterway shafts were so constructed that they could be used for drainage; Yonkers tunnel can be drained, without pumping, thru the Bryn Mawr steel pipe, which connects with its north end under pressure, by means of a blow-off.

A pressure tunnel was adopted for delivering the water in New York City instead of laying a great number of large pipes in the streets, with the accompanying intolerable annoyance. This tunnel secured many advantages and accomplished a saving of $15,000,000 as compared with pipe lines. It is by far the longest tunnel in the world, being almost 18 miles in length.



PROFILE OF CATSKILL MOUNTAIN WATER SUPPLY SYSTEM FROM GILBOA DAM TO SILVER LAKE TERMINAL RESERVOIR, SHOWING THE ELEVATIONS OF THE RESERVOIRS AND OF THE DIFFERENT PARTS OF THE AQUEDUCT

At a few places where the aqueduct when in use would be under only slight pressure it was built of concrete, heavily reinforced with steel rods.

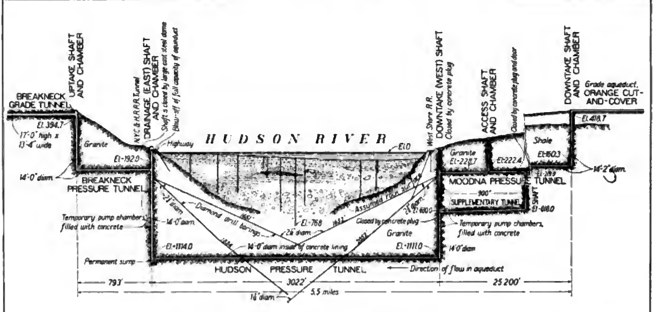
To get Catskill water to Staten Island, the most formidable barrier of all had to be negotiated; namely, the Narrows of New York Harbor, with all the difficulties of great depth of water, wind, tide, fog, and heavy traffic. For this crossing an improved type of ball-and-socket cast-iron pipe, 3 feet in diameter, was devised.

The size of the cut-and-cover conduit is apprehended when compared with a railway car, and its relation to other aqueducts in cross-section is shown by drawing them side by side to the same scale.

SURVEYS

Altho the topographic maps of the United States Geological Survey covered the region, and a few detail maps had been made by predecessors of the Board of Water Supply, it was still necessary, in order to determine the most suitable exact locations for the aqueduct, the reservoirs, and their appurtenant structures, to run about 3000 miles of line surveys, take topography of tens of thousands of acres, dig hundreds of test pits and drill thousands of holes into the earth, aggregating, if put end to end, 45 miles in depth. Thru winter's snows and summer's heat, across frozen rivers and up rocky precipices, these surveys were pushed.

At Olive Bridge and all other dam sites, along the aqueduct, particularly at tunnel locations, and in the city streets, wash and diamond drill borings were made under the guidance of engineers and geologists to learn the nature of the ground to be excavated, the depth to rock, and its character. This information was needed, so that the most appropriate type of structure might be selected, economically located, and intelligently designed; so that many problems might be solved in advance, and so that contractors, having ample knowledge of conditions, might safely make lower bids for construction. Similar explorations were made for quarries and sand pits. By means of diamond and shot drills, cylindrical cores of rock were obtained, varying from ¾ inch to 5 inches in diameter and from a fraction of an inch to 10 feet in length. Carefully selected cores, sufficient to show the character of all the rocks investigated, have been fully labeled and systematically deposited in places of safe keeping in the city and along the aqueduct so that they may be available for further study in connection with future water supply or other projects or for the advancement of the geological knowledge of the region.



CROSS-SECTION OF HUDSON RIVER CROSSING, LOOKING SOUTH, TOWARD WEST POINT

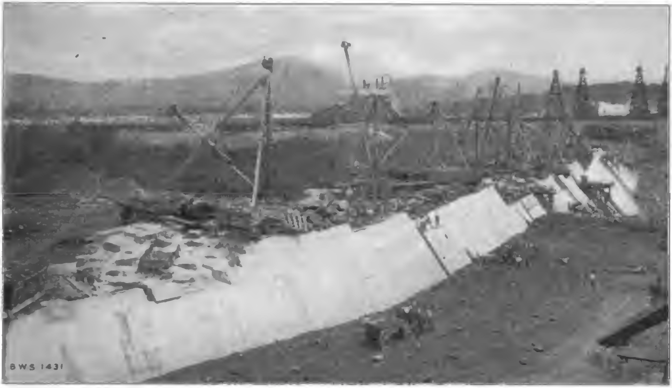
Of all the geological explorations, the most difficult, the most tedious, and yet the most interesting was the search for a Hudson River crossing. Bridges, submerged pipes and other suggestions were rejected in favor of pressure tunnel because of the great economy of the latter and its superiority in other respects. Supplementing extensive surface examinations of the regional geology, drillings were made across the river, between Poughkeepsie and West Point, at six places which seemed to have possibilities, choice finally falling on the northerly gate of the Highlands, where a gneissoid granite forms Storm King Mountain on the west, Breakneck Ridge on the east, and the bed of the river. The depth to rock in the pre-glacial gorge had to be learned. Many endeavors were made to determine points on the rock surface by drilling from a number of scows anchored in the river, but the tide, storms, and traffic, as well as the depth and nature of the glacial filling of the gorge, made progress slow and uncertain. At a few points near shore rock surface was reached, and ultimately a drill in the middle of the river attained a depth of 768 feet, but without encountering rock, before it was swept from its location by a colliding tow of barges.

To obtain more complete and dependable information, in February, 1907, the Board began sinking a test shaft on each margin of the river. Two hundred and fifty feet below the river surface a chamber was excavated in each shaft, and diamond drill borings inclined 45 degrees were started toward the middle of the valley. These attained a depth of 1500 feet, having yielded excellent samples of rock thruout their lengths of approximately 2000 feet. Next a pair of holes at half this inclination was undertaken in the anticipation that they might pierce the gorge surface. Instead, they continued in rock to an intersection 950 feet below river level. It being unnecessary to pursue the investigations further, the tunnel was located at the minimum required depth in sound rock (150 feet) below the intersection of the second pair of drill holes; *i.e.*, 1100 feet below the river surface. Meanwhile, shaft sinking had been continued and in March, 1911, reached the predetermined depth for the tunnel, having continued in suitable rock from top to bottom.

Surveys were completed and contracts were prepared *first* for those portions of the system which would require the longest time for construction. Construction on a large scale was begun early in 1907. Catskill water was first used in New York in 1915 and in regular service in 1917.

THE RESERVOIRS

Gilboa dam will have its top 1150 feet above tide, or slightly higher than the church spire shown in the illustration. It will have a total length of 2330 feet, of which 1330 feet will be masonry, with a maximum height above stream-bed of 155 feet. Schoharie reservoir will extend six miles upstream and have a capacity of 22,000,000,000 gallons. At the central part of the dam site the creek flows in a rocky gorge, and just downstream passes over a small power dam.



OLIVE BRIDGE DAM, SHOWING METHODS OF CONSTRUCTION. FOUR STEEL CABLEWAYS SUSPENDED BETWEEN TOWERS SPANNED THE VALLEY AND DELIVERED MATERIALS, WHILE STIFF-LEG DERRICKS PLACED THE STONES AND CONCRETE IN THE DAM. IN THE BACKGROUND ARE THE CONCRETE MIXING PLANT AND THE YARD WHERE THE CONCRETE FACING BLOCKS WERE CAST

In the valley now filled by Ashokan reservoir were seven villages, with a population of 2000 people, 32 cemeteries containing 2800 bodies, 11 miles of railroad, and 64 miles of highway. This reservoir is 12 miles long and its shore line 40 miles. The maximum depth of water, back of Olive Bridge dam, is 190 feet, and if the water were spread over Manhattan Island it would cover it to a depth of 30 feet, or up to the third-story windows.

At the site of Olive Bridge dam, Esopus Creek flowed thru a rocky gorge 40 to 50 feet deep and 200 feet wide. In a dry season two coffer-dams were thrown across the creek and two 8-foot steel pipes laid, spanning the space to be occupied by the foundations of the dam. As the masonry was built up, a conduit 40 feet wide and 40 feet high was formed thru the dam to convey the stream until the time should come for filling the reservoir. The dam was built in sections 85 feet long between expansion joints provided to care for slight movements due to changes of temperature, without permitting leakage. It was faced on both sides with large concrete blocks cast in advance. Four great cableways and many derricks handled the materials. Earth for the extensions of the dam was brought in railway cars, spread with scrapers, and compacted with heavy, grooved, steam rollers. On some dikes the earth was delivered by cableways which dumped their loads in the air, and on others the core-wall, built up in successive stages, was used to support the railway which hauled the earth. Woodstock dike carries a portion of the relocated Ulster and Delaware Railroad, while most of the other dikes have brick-paved highways on their tops. In the dividing dike is the upper gate-chamber where the aqueduct begins and the admission of water from either or both basins of the reservoir is controlled; at the top of the Beaverkill dikes is the *lower* gate-chamber.

The conduit through Olive Bridge dam was closed in September, 1913, and the water of the creek collected in the reservoir. The completed dam with full reservoir makes an impressive picture with its mountainous background. After preliminary partial fillings and emptyings to wash the reservoir bottom, which had been cleared of all vegetation and structures, water flowed over the waste weir in December, 1916, thus marking the first complete filling of both basins. As practically the whole flow of the stream enters the west basin, the east basin is filled by the water passing over the dividing weir beneath Ashokan Bridge.

To replace the means of traffic submerged, 11 miles of new railroad were constructed on the northerly side of the reservoir, and 35 miles of new highways were built, paved with bituminous concrete, supplemented by five miles of brick highways on the dams and dikes. Stream and railroad crossings necessitated ten bridges in these highways, all of which are of reinforced concrete, the longest, Ashokan Bridge, being 1120 feet, with fifteen arches. Esopus Bridge, at the western extremity of the reservoir, has five arches of 67½ feet span, and Traver Hollow Bridge, with a span of 200 feet, rises 100 feet above the picturesque brook which flows beneath.

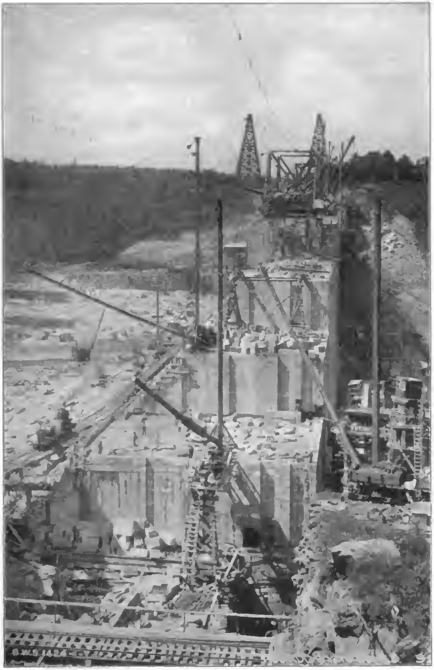
ASHOKAN RESERVOIR, SHOWING PORTIONS OF THE BEAVERKILL AND DIVIDING DIKES, THE LOWER AND UPPER GATE-CHAMBERS, ASHOKAN BRIDGE, AND THE DIVIDING WEIR UNDER THE BRIDGE. THE EAST BASIN IS IN THE BACKGROUND

Viewed from High Point Mountain, at an elevation of 3000 feet or more, Ashokan reservoir spreads out like a beautiful lake. It is almost as long as Manhattan Island, and its dams and dikes, if put end to end, would extend from the Battery to the Metropolitan Museum of Art. Its capacity is 132,000,000,000 gallons.

In the basin chosen as the site of Kensico reservoir were Lake Kensico and the two Rye Ponds, supplying the Williamsbridge district in the Bronx thru the 48-inch Bronx pipe line. The best site for Kensico dam crossed Lake Kensico a few hundred feet upstream from the little dam built in 1885. It was therefore necessary to drain this reservoir, but, as the supply could not be interrupted, two temporary reservoirs were built farther up in the basin and connected to the Bronx conduit by a 36-inch steel pipe, to serve temporarily. The surface of the new reservoir is 110 feet higher than was that of Lake Kensico and is 3½ square miles in area. In emergency it alone could supply the city for several weeks. Its capacity is 38,000,000,000 gallons, maximum depth 155 feet and average depth 52 feet. Only one small hamlet was disturbed in order to build this reservoir.

Having drained Lake Kensico, very deep and extensive excavations for the foundations of the new dam were made by means of steam shovels and standard-gauge railroads, since sound rock was at great depth below the surface in the valley bottom. To place the million cubic yards of masonry in Kensico dam the contractor adopted special equipment and methods. Stiff-leg derricks of unusually great capacity were mounted in sets on travelers supported on wide-gauge tracks carried on concrete piers built into the dam as the masonry rose in lifts of 25 feet. Supplies were brought to the derricks on standard-gauge tracks. So successful was the system that nearly a half million cubic yards of masonry were laid in one season, reaching a monthly maximum of 84,500 cubic yards. By resourcefulness and energy, the contractor completed the dam nearly four years in advance of contract requirement.

Because of its nearness to the city and ease of access by railroad and highway, and because so few of the structures of the waterworks system will be seen by people of the city, it was decided to give this dam a fitting architectural treatment and landscape setting. It is the terminus of the Bronx valley parkway and already attracts thousands of visitors every week. Its downstream face is of beautiful granite found in a hill about one mile east of the dam, where a quarry was opened by the contractor. The stone is boldly cut and carved in keeping with the massiveness of the great structure, which is 1908 feet long, including the end pavilions, and rises 140 feet above the present surface of the ground. Kensico reservoir necessitated the construction of 15 miles of new highways and the building of four bridges, most notable of which are the three-arch stone bridge connecting the easterly end of Kensico dam with the State highway, and Rye outlet bridge, crossing a narrow portion of the reservoir about two miles north of the dam.



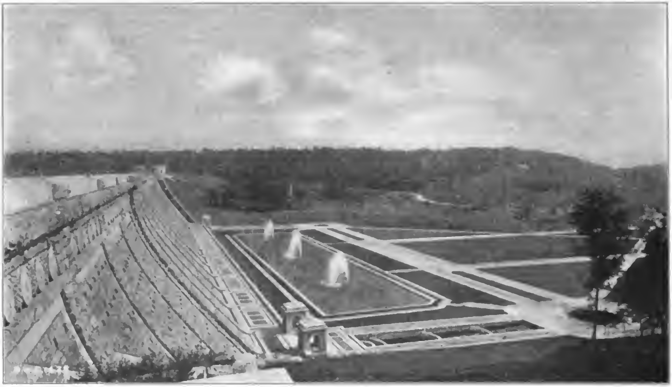
Kensico dam during construction, showing the division of the dam by the expansion-joints. The two cableways spanning the valley aided in handling materials and equipment. The system of derricks on travelers and the single derricks, for placing stones and concrete, are also shown, as well as the railroad tracks for delivering materials to the derricks

To create Hill View reservoir, 3,000,000 cubic yards of earth had to be excavated by steam shovels and placed in embankments to build up the sides of the excavation. A great wall, slightly submerged when the reservoir is full, divides the reservoir into two basins for convenience of operation, the lower part of the wall containing a by-pass aqueduct so that water can be brought into the city without entering the reservoir, whenever necessary. To facilitate cleaning, the bottom and lower slopes of the reservoir are paved with concrete and the upper portions of the slopes are covered with stone paving. The water rises into the reservoir at its northerly end thru a shaft from the Yonkers pressure tunnel and is drawn into the city tunnel thru a downtake shaft at the southerly end. Over each shaft is a large gate-chamber in which the flow of water is controlled. The capacity of this reservoir is 900,000,000 gallons, and the depth of water 36½ feet.

Silver Lake reservoir is in a natural depression. It also has been divided into two basins, with controlling gate-houses in the dividing dike. Its capacity is 435,000,000 gallons. These gate-houses, like those at the other reservoirs, are of cut cast-concrete stone, adopted because of its excellent qualities and economy. Like other reservoir gate-houses and the buildings along the aqueduct, they are roofed with reinforced concrete tiles, similar in general form to the cut-stone tiles used on the roofs of Greek temples centuries ago. This type of roof was adopted for permanence, to withstand severe climatic conditions, and to resist the occasional mischievous person's stone or rifle shot.

THE AQUEDUCT

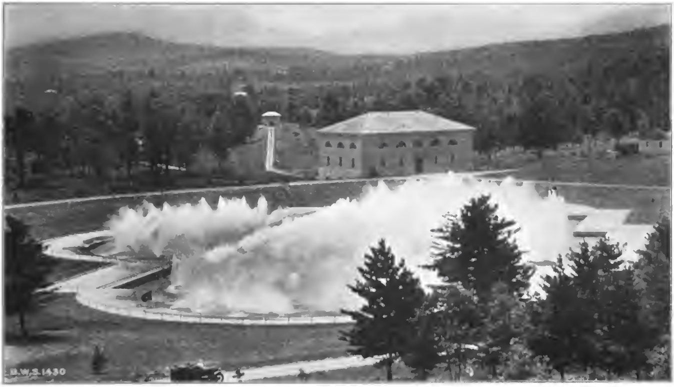
Starting in the *upper* gate-chamber of Ashokan reservoir, the aqueduct, of double capacity, is carried in a deep rock trench beneath the Dividing and West dikes to the lower gate-chamber, where the flow of the water is regulated by means of numerous valves oper-



DOWNSTREAM FACE OF KENSICO DAM AND THE UNFINISHED PARK BELOW, LOOKING FROM THE PAVILION AT THE WEST END OF THE DAM ACROSS THE TERRACE AT THE BASE OF THE DAM, THE POOL, WITH THREE KINDS OF JETS BEING TRIED AND THE CASCADE BASINS

KENSICO DAM AND RESERVOIR AND KENSICO BRIDGE NEAR COMPLETION, VIEWED FROM THE STATE HIGHWAY, WHICH PASSES ALONG THE EASTERLY SIDE OF THE RESERVOIR ated by electric power generated in the building by the flowing water. From this chamber the water is diverted generally to the aerator and thence to the screen chamber, but may be sent directly to the screen chamber, where it is passed thru fine screens to remove leaves, fish, and other floating objects. To this building the aqueduct is in duplicate and of special construction. At the south side of the screen chamber the standard aqueduct, of the cut-and-cover type, of 500,000,000 gallons daily capacity, begins.

In constructing cut-and-cover aqueduct, a trench was roughly dug with steam shovels with a bottom width of 21 to 30 feet, according to the character of the earth or rock, the rock, of course, being blasted to prepare it for the shovel. After hand trimming of the trench, the curved bottom, or invert, was placed in alternate 15-foot sections, like a sidewalk, with special joints between. At some places under-drains for ground water had to be provided; at others, soft earth removed or consolidated, or special supports constructed under the aqueduct; at a few small depressions very carefully compacted embankments were built as foundation.



ASHOKAN AERATOR AND THE BEGINNING OF THE CATSKILL AQUEDUCT. THE LARGE BUILDING IS THE SCREEN CHAMBER, AT WHICH THE STANDARD AQUEDUCT BEGINS. FOLLOWING THE AQUEDUCT EMBANKMENT, ONE COMES FIRST TO THE GAGING CHAMBER AND, TO THE LEFT, THE TWO CHAMBERS OF THE ESOPUS STEEL-PIPE SIPHON. THE LOWER GATE-CHAMBER IS JUST OUT OF THE PICTURE AT THE RIGHT

Following the invert, collapsible steel forms of the shape of the inside of the aqueduct were set up in sections of various lengths, and outside them other forms, with space between equal to the thickness of the walls and arch. In a few cases wooden forms were used, and the outside forms were sometimes partly of wood. The inside forms were coated with grease to prevent adhesion of the concrete and secure a smooth surface for contact with the flowing water. The forms having been prepared, concrete was brought from a nearby, or sometimes a distant, mixing plant, in steel buckets on cars drawn on tracks laid alongside the trench. Arrived at destination, the buckets were lifted by a locomotive crane, swung over the forms and dumped, this process being continued until the arch had been completed. Stretches of 30 to 75 feet of aqueduct constituted a day's work. After the hardening of the concrete, the forms were removed, the completed aqueduct covered with earth, and the surface of the embankment planted with grass. In very deep cuts only part of the depth was refilled, three feet of cover over the aqueduct being sufficient. Altogether there are 55 miles of cut-and-cover aqueduct, divided among many contracts, and interrupted by the tunnels and steel-pipe siphons.

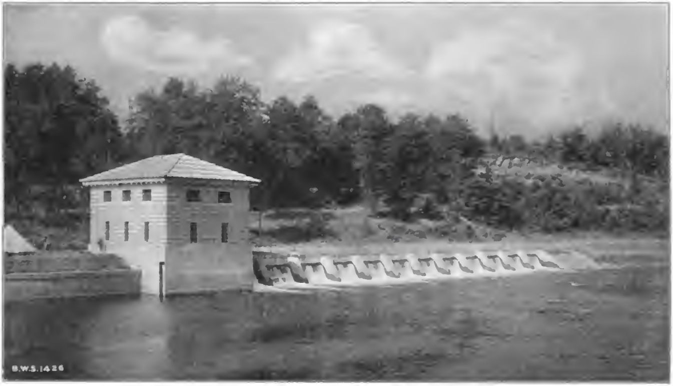
Kensico reservoir is the first place where water is normally delivered from Catskill aqueduct. Here a long covered weir of special construction admits the water, and from the gate-house at its end a reinforced concrete by-pass, 11,000 feet long, extends under the margin of the reservoir to the upper effluent gate-house. At the latter water can be drawn either from the reservoir or from the by-pass.

In building the steel-pipe siphons, so-called, sections of pipe 15 feet long, temporarily coated with whitewash to retard rusting, were delivered alongside the trench, in the bottom of which cradles of concrete had been built. The pipes were lifted into the trench, riveted together, filled with water when completed across the valley, and, while under this normal water pressure, covered with concrete. After this concrete jacket had hardened, the water was removed. The mortar lining was placed by pouring it thru small pipes set in holes left for the purpose thru the concrete jacket, into the space between the inside of the pipe, and forms placed in it. Over the chambers at the ends superstructures have been erected, some of brick with concrete-stone trimmings, others wholly of concrete stone, and a few of local stone, with Concord (New Hampshire) granite trimmings. These steel pipes aggregate six miles in length.

In constructing many of the tunnels the first step was shaft sinking. After starting the digging at the surface, a simple type of head-frame was erected for the hoisting machinery, and both men and materials were lowered into and lifted from the shaft by means of steel buckets hanging at the end of a wire rope. When the shaft had been sunk to tunnel level, a more substantial head-frame was set up and elevators were installed for greater rapidity and safety of operation during the driving and lining of the tunnel.

Methods of excavating grade and pressure tunnels were similar. All tunnels are of such large dimensions that the rock was removed by two operations. Usually the upper part of the tunnel was driven first as a heading and the lower portion removed as a bench, but in a few cases the lower part was taken out first. Drills, operated by compressed air, were used for driving approximately horizontal holes in the heading and vertical holes in the bench. These holes were loaded with dynamite, which was exploded in proper sequence. The broken rock, or " muck," was shoveled into wheelbarrows and dumped into small cars, or shoveled directly into the cars, altho in a few cases special machines were used. The cars were drawn by mules or electric locomotives to either a portal or the bottom of a shaft and run out on waste piles, or to a rock crusher to be used for concrete material.

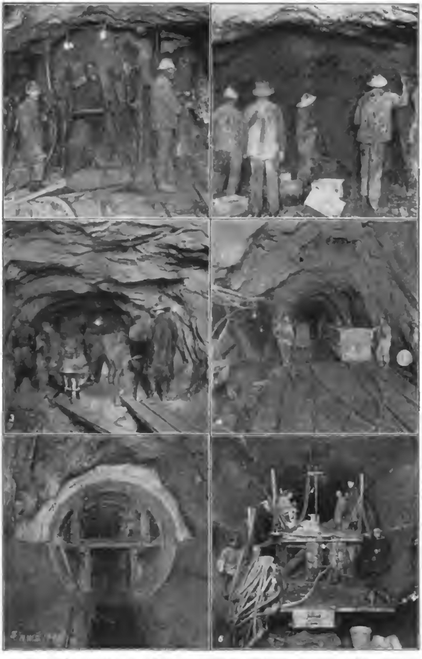
Altho exploratory borings enabled the engineers to locate the tunnels so as to avoid many difficulties, all could not be eliminated. At some points large quantities of water were encountered which had to be removed by pumping or shut off by stopping with grout the crevices in the rock. In some places the rock was not sufficiently sound to form secure walls and roof and had to be supported. Much of this support was of wood and was removed as the concrete lining progressed; but in the grade tunnels some wooden support was left in place, and in the pressure tunnels permanent steel support was necessary for short stretches.



KENSICO INFLUENT WEIR AND CHAMBER WHERE THE CATSKILL ENTERS KENSICO RESERVOIR. THE KENSICO BY-PASS AQUEDUCT BEGINS AT THE LEFT SIDE OF THE CHAMBER

In lining grade tunnels the side walls and arch were completed first, and then the bottom of the tunnel was cleaned out and the invert placed as the construction tracks were removed. When completed, there is little to indicate on the surface of the ground, even at the portals thru hills, that a tunnel has been constructed.

In lining pressure tunnels the invert was constructed first, upon which semicircular steel forms were erected for the remainder of the lower half of the lining. Having completed the lower half, or side walls, similar forms were set for the upper half, or arch. In some cases side wall and arch forms were carried along together and concrete placed in adjacent sections simultaneously. There are 24 grade tunnels, aggregating 14 miles, and seven pressure tunnels north of the city, totaling 17 miles.

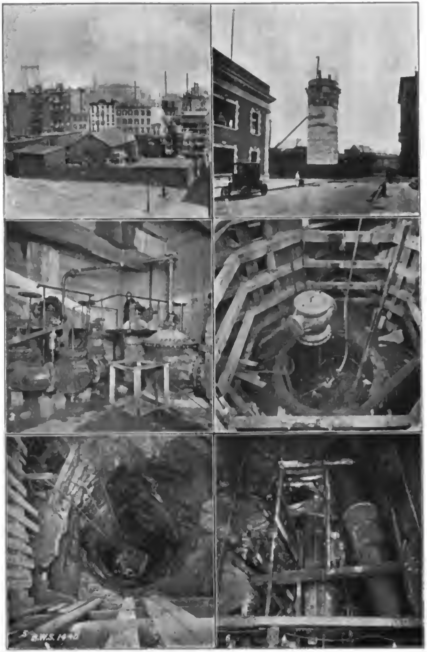


PRESSURE TUNNEL: (1) DRILLING TUNNEL "HEADING" AND "BENCH"; (2) LOADING DYNAMITE INTO THE HOLES; (3) REMOVING THE "MUCK"; (4) HAULING "MUCK" OUT AND CONCRETE IN; (5) PLACING CONCRETE LINING AROUND STEEL FORMS; AND (6) GROUTING CREVICES IN THE ROCK BACK OF THE LINING

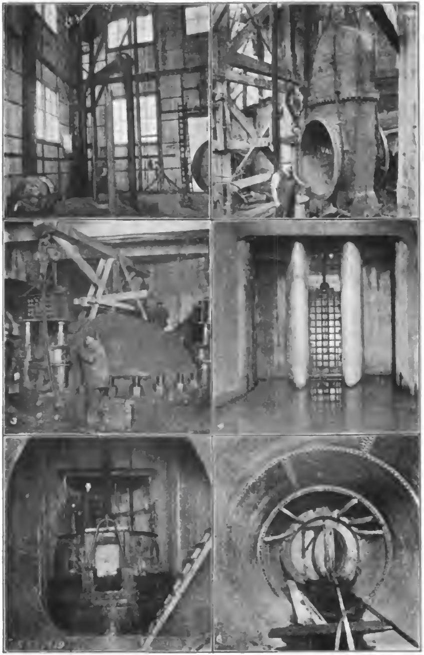
Of all the pressure tunnels, the Hudson River crossing has attracted most interest, undoubtedly because its site is so familiar. In order to construct the connecting shaft and tunnel in Breakneck Mountain, on the east side of the Hudson, the contractor laid an inclined railway up the side of the mountain. The entrance to the grade tunnel thru Breakneck Mountain is now marked by a small granite building 414 feet above the river. Since the east shaft is utilized not only as a waterway, but also for drainage and access, and since its top is 410 feet below the hydraulic gradient of the aqueduct, it was necessary to close it against this enormous water pressure with a cover which could be conveniently removed, of sufficient size to permit the introduction of the pumping apparatus used for unwatering pressure tunnels. This cover is a cast-steel dome, in one piece, weighing nearly 50 tons, and is held in place on a cast-steel curb ring by 36 tempered nickel-chrome steel bolts, 4½ inches in diameter, 50 feet long, extending down in the concrete lining of the shaft to a cast-steel anchor ring. In order that the joint may be watertight with changes of length of the bolts due to changes of temperature, the bolts are stressed, each time the cover is put on, with hydraulic jacks, so that they always pull the cover against the curb ring. The water pressure on the cover is 180 pounds per square inch, making the incessant lifting force 4,000,000 pounds, and yet this joint, 50 feet in circumference, is as tight as a cork in a bottle. This cover has been placed and removed several times successfully.

For the city tunnel shafts it was required that the temporary structures be as compact and neat as practicable; the one near City College is typical. In Brooklyn and the lower east side of Manhattan the rock was at such depths below the surface of the streets (65 to 146 feet), and also so far below groundwater level, that these shafts could not be started in the ordinary way. Instead, the concrete lining of the shaft, heavily reinforced with steel rods, was built in advance above ground, like a tower, and sunk as a caisson by excavating from within, compressed air being used below water level. The bottom of each caisson went a few feet into the rock and was tightly sealed thereto. Afterward shaft construction proceeded in the usual way.

In the midst of the city extraordinary precautions were demanded in handling the dynamite necessary for tunnel driving. As soon as each shaft had been sunk and the tunnel started, a magazine chamber was ex-



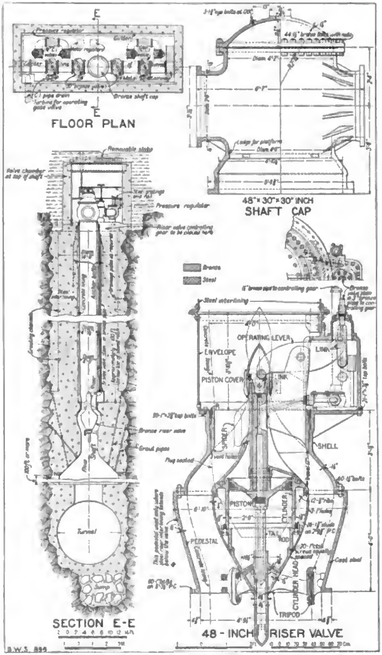
Contractor's plant at the top of a City Tunnel shaft (1); (2) a reinforced concrete caisson being sunk through sand to rock for a shaft in Brooklyn; (3) interior of a valve chamber on top of a finished shaft; (4) a shaft top nearing completion, showing a riser pipe and shaft cap; (5) looking down into a shaft during the process of sinking; and (6) steel riser pipes in a shaft ready to be imbedded in concrete



The building over a drainage shaft showing the discharge pipe and power, lighting and telephone cable reels (1); (2) a huge bronze valve ready to be lowered into a City Tunnel shaft; (3) the steel dome and anchor bolts on top of the Hudson Drainage shaft; (4) the connection chamber and a sluice-gate at the junction between a steel-pipe siphon and cut-and-cover aqueduct; (5) the unwatering equipment in the Hudson pressure tunnel, at the bottom of the drainage shaft; (6) the bronze door in a drift connecting an offset drainage shaft with a pressure tunnel cavated at one side of the tunnel and guarded by a door of special construction, so arranged that it would close instantly in case of an explosion within the magazine, thus preventing the force of the explosion and the objectionable fumes from reaching the tunnel or the streets above. During three years of active tunnel driving 10,000 pounds of dynamite were used day after day without serious accident.

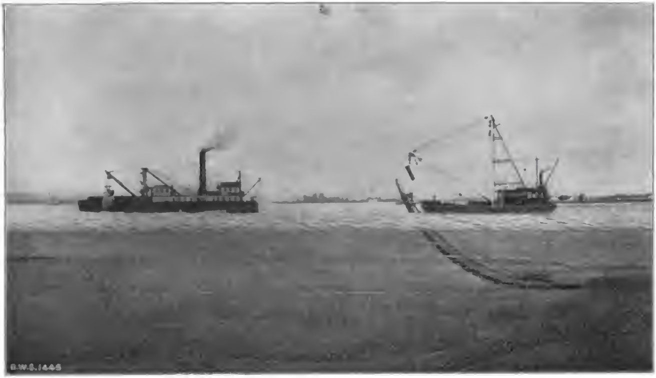
For constructing the city tunnel, 25 shafts were required, ranging in depth from 200 to 750 feet, the latter being as deep as Woolworth tower is high. The shallowest shafts are in the central part of Manhattan and the deepest in the lower East Side. These shafts were required not only for constructional purposes, but also as waterways from the tunnel to the distribution pipes. Consequently their lower portions were lined with concrete and the upper portions, from a depth of at least 100 feet in sound rock, were closed with concrete plugs, in which were imbedded one or two steel pipes lined with concrete so as to form waterways 48 inches or 72 inches in diameter.

At the bottom of each pipe is a riser valve, which can be operated from the chamber, for shutting off the flow of water in the event that other means of stopping flow have failed in some exigency, or must be removed for repairs. These valves are also intended to close automatically in the event of a break above causing a great flow of water. The special casting at the top of each riser is known as a shaft cap and is of bronze, as are the two valves bolted to it. At the top of each shaft, under the street or park surface, is a large concrete chamber containing the connections, controlling valves, and meters. Waterways and means of shutting off the water are of the most permanent materials —masonry or bronze, or steel imbedded in masonry—from the tunnel to and including the valves bolted directly to the shaft caps. Possibility of interruption of the flow of water from any shaft is thus minimized. The relations between tunnel, shaft, and street pipes and the buildings above are well illustrated by the panorama at Madison Square.



SECTIONS OF A TYPICAL SHAFT AND CHAMBER OF THE CITY TUNNEL, WITH DETAILS OF A RISER VALVE AND SHAFT CAP

In crossing the Narrows, a deep trench was first excavated by dredges and then the pipe was laid, beginning at the Brooklyn shore, by means of a powerful derrick boat, specially equipped, carrying suspended from its bow a hinged bridge which extended to the bottom of the trench on a curve that could readily be assumed by the pipe line as the pipes were put together. The inside of the bell, or socket, of each pipe was ground and polished to a mirror-like surface, accurately spherical. Into the space between it and the spigot end of the next pipe molten lead was poured, and after this lead had chilled and shrunk, the slight space resulting was filled by forcing in slugs of cold lead through 32 holes drilled around the bell of the pipe. For forcing in these slugs special steel screws were used, driven by quick-acting devices. In this way a joint was secured which, while retaining its watertightness, would permit the required movement and allow the pipe line to adjust itself to a bearing on the bottom of the trench. Immediately after completion, tests showed that this pipe line, 10,300 feet long, with joints every 12 feet, under a pressure of 130 pounds per square inch, leaked 5½ gallons per minute; and a few months later, under service pressure of 100 to 110 pounds, a 40-day test gave an average total leakage of ¾ gallon per minute—



LAYING THE NARROWS SIPHON FROM BROOKLYN TO STATEN ISLAND. AT THE LEFT IS THE CLAM-SHELL DREDGE BOAT WITH ITS SCOWS AND AT THE RIGHT THE PIPE-LAYING BARGE AND THE SUBMERGED BRIDGE USED TO SUPPORT THE PIPE-LINE AS IT WAS PUT TOGETHER. THE BARGE AND BRIDGE WERE MOVED FORWARD AS THE PIPES WERE ADDED TO THE LINE SO THAT THE PIPE LINE WAS PAID OUT LIKE A CHAIN INTO THE BOTTOM OF THE TRENCH. SUBSEQUENTLY THE PIPE WAS COVERED OVER WITH SAND AND GRAVEL

truly remarkable! This pipe was covered with sand and gravel to a depth of 8 feet to protect it from injury by anchors or foundering vessels and other possible causes of damage. A second pipe line will be needed to convey the total supply required by Staten Island and provide against possible interruption.

WELFARE AND POLICE

Welfare work for the forces of the Board and its contractors received constant attention. So far as practicable, camps were located outside of watersheds used as sources of water supply. Where this could not be accomplished, purification works for the wastes and vigilant patrols were used to prevent pollution. With few exceptions, all garbage and excreta were incinerated and drainage chemically treated or filtered, or otherwise safely disposed of. Each contractor was required to maintain competent physicians, trained nurses, and adequate hospitals, and to examine all employes before admitting them to camp.

To make life more agreeable for the men and help them to self-betterment, especially in the larger camps, evening schools, clubs, amusements, Young Men's Christian Association quarters, and other facilities were provided. In some instances prizes were offered for the best garden. Day schools were maintained for the children. In one camp a post-office and a bank were established. Most camps had general stores or commissaries. Usually camps were on lands provided by the city, and undesirable camp followers and intoxicating liquors were excluded. Little trouble arose in any of the regular camps. Such troubles as did occur were chiefly in the " outside " camps, over which neither the city nor its contractors had control, on land rented by irresponsible parties from local citizens whose desire for profit overcame their sense of morality and public decency.

A commendable record was made for orderliness and healthfulness. No epidemic occurred among the laborers nor in any community in which laborers connected with the work were quartered, nor in communities on whose watersheds camps were situated. As a result of this attention to the human side of construction and of the influence of the camp schools, in which the men were instructed in the English language and American institutions, a better class of laborers was secured and **there were no strikes.**

Just as the Board of Water Supply was beginning its work, the Legislature passed a law requiring the Board to create a police force for the maintenance of law and order in the camps and for the protection of communities in or near which work was to be done. This force was uniformed and organized on lines somewhat similar to those of the city police, with suitable modifications for rural conditions. It reached a maximum of 387. Most of the men were on foot, but there was a mounted squadron for special duties, and some of the men were equipped with bicycles and a few with motorcycles.

ADVANTAGES AND COST OF SYSTEM

One great advantage of the Catskill water supply is that its reservoirs in the mountains are at such elevations that the water can flow to the city by gravity and be delivered at such pressures that it will rise without pumping to the levels necessary for service in practically all parts of the city, in buildings of reasonable height.

It has been estimated that pumping, costing the city and private individuals approximately two million dollars per annum, can be eliminated. A gravity water system, requiring but few men for its operation and most of them unskilled, is but little affected by rises of wages or by labor troubles. This great gravity supply, from which 375,000,000 gallons daily have been drawn for months, has been of inestimable value to the metropolis in this severe winter with the scarcity of fuel caused by the country's unpreparedness for wartime conditions.

Catskill aqueduct reaches all boroughs of the city and inter-connects the other permanent supply and distribution systems as has never been done before.

The first portion of this system has been completed within the anticipated time and at less than the expected cost. The estimated cost of the entire work was $177,000,000, to which subsequent legislative action added $8,000,000, making the total revised estimate $185,000,000. Disbursements and liabilities to October, 1917, amounted to $139,000,000, and the estimated cost of completing the whole system, including $22,000,000 for the Schoharie project, is $37,000,000, a total of $176,000,000—$1,000,000 less than the engineer's original estimate, and $9,000,000 less than the estimate corrected for expenses added by legislation.*

IN CONCLUSION

This description of the physical works which make up New York's Catskill Mountain water system must be supplemented by mention at least of the ability and resourcefulness of the contractors, many of them engineers, who wrought with the Board of Water Supply and its staff, of the ingenuity of manufacturers who furnished materials and equipment, of the generosity of engineers in many parts of the country who contributed information and suggestions from their experiences, and of the coöperation of city and state officials. The commissioners of the Board of Water Supply are Charles Strauss, president; Charles N. Chadwick and John F. Galvin. J. Waldo Smith has been chief engineer from the beginning.

When, hereafter, a citizen of New York gazes upon beautiful Kensico dam he must remember he is enjoying the fruits of the labors of many men, expressed by this imposing structure as the token of the underground artificial river and its lakes by means of which water from the distant mountains is constantly available for every use in the homes and marts and factories of the metropolis. And so substantially have these works been built that they should still be useful after the lapse of centuries. But New York's water problem has not been permanently solved; with continued rapid growth it will soon be necessary to take preliminary steps toward the next increment, for ten or even twenty years hence are but as to-morrow in dealing with this city's gigantic public works.

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* Important items of such legislation were the decrease of the legal length of the working day from ten hours to eight, the requirements for a special police force, and the workmen's compensation act dealing with injuries and insurance.

THE WAR ON LAND AND SEA*

BY WILLIAM L. CATHCART

MY subject, "The War on Land and Sea," is almost world-wide, and in a swift review only its most important points can be treated.

In starting, may I express my regret that severe language must be used in characterizing Germany's conduct of this war. For, in this country, there are many loyal citizens of German birth or descent who have our sympathy and respect. Liberty-loving men, like Carl Schurz and Franz Siegel, driven here from beyond the Rhine in 1848, have left an honored impress on our history, and they have their successors among Americans of German birth to-day.

But the Germany of the old time which these men represent—the land of song and story, of art and music, of science for noble ends—vanished long ago. In its place there has arisen under Prussian training a pagan nation.

As to this, Otto Kahn, the New York banker, an American of German birth, says:

"From each successive visit to Germany for twenty-five years I came away more appalled by the sinister transmutation Prussianism had wrought among the people, and by the portentous menace I recognized in it for the entire world.

"It had given to Germany unparalleled prosperity, beneficent and advanced social legislation, and not a few other things of value. But it had taken in payment the soul of the race. It had made a 'devil's bargain.'"

And to Mr. Kahn's words I may add that, from the beginning, the main part of that bargain was this war, the mighty conflict which has no parallel in history. For more than thirty years the Prussian Government has made secretly planned war for world-dominating aims the chief industry of its subjects. To further these aims—in their political and financial bearing—sinister German intrigue has been active everywhere. From Bagdad to Buenos Aires there is no land now which is not stained by the slime of German plotting, of German money lavishly spent for basely treacherous ends.

The genesis of this war, its atrocious character, and the relation of the German people to these elements may seem to have no place in a technical analysis of its military features. But—as I shall show—they have a grave effect on the war's duration and on the peace terms which it will be necessary to impose. Hence they should be considered. First, take the character of German warfare on land.

GERMAN WARFARE ON THE LAND

When its time for action came, Germany leaped on a world at peace like a tiger from the dark. Into Belgium and France she sent the most savage and bestial armies that ever dishonored any flag. Not content with crushing the relatively weak military forces which at first opposed them, they assailed defenseless womanhood, dragged into shameful slavery the conquered peoples, bombarded the age-old shrines of the Christ, and now, in their slow retreat, they are making of the sunlit fields of France a desolation—gray as that of Pompeii and Martinique!

On August 26, 1914—a month after war began—the German General Stenger issued this order to his brigade:

"To date from this day, no prisoners will be taken. . . . The wounded, whether armed or defenseless, will be executed. . . . Not a man will be left alive behind us."

This is not warfare, but murder. The similar murders of unarmed civilians—old men and women, youths, and little children—are numbered by thousands in Belgium and France. In sixteen places there were shot or bayoneted 3358 of these inoffensive people, of both sexes and ranging in age from three weeks to 77 years.

In an official report to the United States Government, Brand Whitlock says:

"In the awful crime of the Rock of Bayard overlooking the Meuse below Dinant (where 90 persons were killed), infants in their mothers' arms were shot down without mercy. The deed never has been surpassed in cruelty by any band of savages."

The Belgian Consul at Baltimore estimates that at least 100,000 Belgians have been torn from their homes and deported as slaves to Germany. Thirty thousand of the population of Lille and the north of France were similarly deported and enslaved. The German official proclamation at Lille reads:

"All the inhabitants of this house—excepting children under fourteen, their mothers, and also old people—must prepare themselves for transportation in an hour and a half's time."

Germany's thefts in Belgium, France, Roumania, and Serbia have been colossal.' Belgium has been stripped to the bone. Altho this little country is only about one-fourth the size of Pennsylvania and has the same population, Germany has taken from it more than two billion dollars in cash, raw materials, machinery, and everything else that was portable. Last winter 147 children froze to death every week in Brussels owing to insufficient clothing and fuel. This winter the Germans have requisitioned all the remaining blankets and all the coal.

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* Presented before the Philadelphia Section, American Society of Mechanical Engineers, January 22, 1918, at the Engineers' Club.

Again, Germans in retreat systematically poison wells, and defile all buildings they cannot destroy. Their airplanes dropped poisoned candy for the children of Roumania, and into that country their diplomats brought the bacilli of glanders and anthrax. They systematically shell hospitals and ambulances, and turn their machine guns on stretcher bearers carrying the wounded. Up to October 1, 1917, German aircraft in raids on England had killed outright 865 non-combatant men, women, and children, and wounded over 2500 more.

And all this is but a rough sketch of Germany's methods in land warfare, which are unrestrained by law, morals, or humanity.

GERMANY'S SEA WARFARE

On the sea the German story is the same. While there have been a few isolated instances of humanity among their naval men, their deeds as a whole in their submarine campaign exceed in malignant cruelty those of the darkest days of piracy. The long annals of the deep hold no fit comparison with them.

During the Battle of Jutland, the huge dreadnought *Lützow,* badly damaged, was steaming too slowly home, and, to keep her from falling into British hands, she was abandoned and torpedoed—sinking with 300 German wounded.

If they do that to their own, what need other nations expect? Nothing, indeed, but the wild orgy of savage murder on the high seas which their submarines have held. With sneering laughter their officers have sent to death thousands of non-combatant men, women, and little children—whose bodies to-night drift pitifully thru those dark ocean depths.

The dead in these submarine atrocities must number at least 8000 now. From four ships alone—the *Lusitania, Ancona, Persia,* and *Falaba*—1902 people were lost, and since then the toll has mounted steadily.

From February 18 to December 22, 1917, German submarines and mines sank 1264 Allied and neutral ships of 6,371,000 tons, total. Since war began this total loss has exceeded 8,000,000 tons, or more than one-sixth of the merchant tonnage of the world in 1914.

Taking this latter figure, and allowing one seaman for every sixty tons' register, this riot of wrecking means that about 134,000 merchant sailors have been either drowned, killed by gun fire, or landed—starving, frostbitten, and destitute—in nearby friendly ports. And this does not include passengers.

Further, Lord Lytton, Civil Lord of the Admiralty, states that, in the three years ending with last October, 122 British vessels had been lost without trace. This means the " spurlos versenkt " business—wholesale murder—for, in peace times, the normal average of missing ships would have been 45.

The calculating cunning of all this is shown by the fact that from August 8, 1914, to April 26, 1917, the Germans sank 849 neutral ships of 1,653,654 tons, total. You see, Germany is running a business war as well as a military one. Her object is to sweep the seas of foreign ships, so that, when peace comes, she will lead in seaborne commerce.

On seven torpedoed hospital ships, 206 people were lost, including 45 Red Cross nurses. You know the story of the *Belgian Prince,* sunk last July. The official report issued by the British Admiralty says:

" The crew abandoned the ship in two boats, and were ordered on to the upper deck of the submarine by the German commander. Under his directions, the boats were then smashed with axes and the crew . . . deprived of their life-belts. (Then) the hatch (was) closed (and) the submarine submerged with 43 men standing on her deck. . . . With the exception of three, all these were drowned."

WHAT THIS WAR IS

In a technical and historical sense, a " war " is a contest between nations or states, waged according to the Laws of War—that is, under the limitations and usages which international public opinion has, from time to time, imposed.

If this is true war, what then is this attack which, for more than three years of " starless nights and hopeless dawns," the German Empire has waged against the men, the women, the little children of Europe?

Its object has been—and still is—not only to dominate the world, but to exterminate little nations, and to loot to the bone all conquered lands.

Bismarck said: " Nothing should be left to the people of an invaded nation but their eyes to weep with." And, God knows, German militarism has done all this and more.

And so the conflict which America has entered is not a " war " in the true sense, but a crusade, a struggle between the massed forces of civilization and those of scientific barbarism—between humane, peace-loving men and beings who, tho human in origin, have the lusts and savagery of nethermost hell.

AMERICA'S JUDGMENT

To the future historian it will seem inexplicable that even a mentality so dense as that of Germany's rulers should assume that this Republic would complacently endure all this; would calmly say with Cain: " Am I my brother's keeper? "; would be blind to its own imminent danger if Germany won.

No! From the moment those horrors began, from the day that Belgium was invaded, the God of Nations sounded a trumpet call to us. And thru the weary years since then—while the tortured air vibrated with the gasping sighs of dying men, the shrieks of violated women, the moans of wounded children—that call has grown ever more insistent.

And at last America answered—stirred to action by the noble ideals of its past, by memories of the men of

Valley Forge and Yorktown, of Monterey and Buena Vista, of Gettysburg, Antietam, and the Wilderness.

And so, above the snows of French Lorraine, there streams in the winter wind a starlit flag. Guarding it there, tensely waiting its leadership, there are now thousands of our gallant lads—the very flower of our young manhood—eager to give, if need be, home and love and life itself for that flag—for you and me.

And they are but the van of the great army that is coming. The "Long Arm" of America has reached out from valley and plain, across mountain and sea, to do its mighty part in smashing kaiserism.

THE KAISER'S RESPONSIBILITY

As to the Kaiser: It is difficult to fix his rightful share in this deluge of blood, this world-wide carnival of crime. For, some well-informed observers say that the "All Highest" is stupid; that he is but the dupe of the "Potsdam Gang," the militarist ring about him.

RESCUED BY A "TOMMY" AT MASNIÈRES.

Thirty years ago in the *New York Times,* Harold Frederic said of him: "Apparently, all the women—at least all the English women—who have had to do with the bringing up of Prince William hold him in horror and detestation. . . . Their dislike for him is based on a general conception of his character. This view is that he is utterly cold, entirely selfish, wantonly cruel; a young man without conscience or compassion, or any softening virtues whatever. . . . Heart he has none, upon their reckoning."

Later, his father, the Emperor Frederick, said: "Be careful of Wilhelm, because he is just as stupid as he is square-headed. He has a religious mania, and is full of bigotry and conceit."

Now let the Kaiser speak for himself. In his proclamation in 1914 to the Army of the East he said: "The spirit of the Lord has descended upon me because I am the Emperor of the Germans. I am the instrument of the Almighty. I am His sword, His agent. Let them perish, all the enemies of the German people!"

Of one thing, at least, there can be no doubt: By Article II of the Imperial Constitution, the Kaiser has the sole right to declare war. Hence, as the man who started this conflict, he has had his wish, in that the so-called "enemies of the German people" have fallen in millions.

His mute accusers are: that graveyard which is Belgium; the forest of white crosses studding thickly the sunlit fields, the wooded hills of France, and the low-lying plains of Flanders; the countless mounds in Italy, in Germany and Austria; and the vast multitude of unburied dead, stretching down the Balkan peninsula and far eastward to Bagdad.

The killed among the combatant forces of both sides average at least three men a minute, night and day, during the forty-two months of this war. The severely wounded—those permanently disabled—are probably one-half as many. And these are conservative figures. Some estimates are much higher.

And this is not all. Indeed, in its iniquity, the death of these six million men is far from being the chief crime of the Kaiser. These men met as soldiers the fate they dared; they fell in battle, slain by the foes they strove to kill. But, what of the non-combatants—the old men, the frail women, the little children?

Only the God of the helpless knows the Kaiser's toll of death on these weak folk within his lines—who have died, *and are dying,* by massacre, by starvation, by illness from want and exposure, or by disease deliberately propagated by their inhuman captors.

These victims number millions now. Beside the first brutal killings in Belgium, the repatriated *deportés* there are mainly dying men, and, despite such outside relief as is possible now, its people are half famished. Tears filled Herbert Hoover's eyes when Belgian children, weak with hunger, feebly sang "The Star Spangled Banner."

Poland's sufferings have been even worse than those of Belgium. Except new-born infants, there are no children under seven years of age alive there now. Famine and disease stalk hand in hand thruout its whole extent. "Warsaw is dying," says a recent press report.

The dead in the Armenian atrocities were more than a million, including all the men of the race. There are more than 400,000 orphans. There and in Syria, two and a half millions are starving.

As to Serbia: It is estimated that one-fourth of the population has already perished from war and privations of every kind. An observer there writes of "that terrible migration that killed its tens of thousands on the limestone mountains, in the scrub oak and the drifting snow."

THE GUILT OF THE GERMAN PEOPLE

But what of the German nation? Has it no share in this blood-guiltiness?

The assumption that the German people have little or no responsibility for this conflict, and that hence we are not at war with them but with their government only, may be wise statesmanship as an aid to German liberalism. But the actual conditions appear to give it little support.

The most vital and powerful element of the German people to-day is their armies in the field. In his heart, the Kaiser dreads those armies more than he does his Allied foes, for it is these six million virile men who—maddened by the war's failure—may force revolution in Germany when peace comes.

Now, it is not the German Government—the Kaiser, his military and civil staffs—that perpetrated the outrages and murders which have shocked the world. But it is these armies in the field, these soldiers who virtually represent the German people of to-day, that are the actual culprits.

To plead that these representatives of the German people were ordered to commit these crimes, and were joined in them by their officers, is futile.

In the first place, there are not more than 400,000 officers in these armies, and they could be readily defied by the concerted action of their men. And, secondly, any officer of the United States Army or Navy who did the unthinkable and gave such orders to his men would be hanged by those men on the nearest tree. And this is true of the armies of our Allies.

Surely this Republic is at war with people guilty of such deeds. A part of the mission of our army in France is to force—not vengeance—but retributive justice and condign punishment for these crimes. Every American soldier who falls there will die at the hands of representatives of the German people.

As to their responsibility for the origin of this war: I need only point out that the vast military and naval expansion of the last ten years had the enthusiastic support of the whole German nation. These people knew that all this meant aggressive war the moment their time to strike came. They knew well the atrocious kind of warfare their armies had waged in the past. And they could not but expect that even this black depravity would be surpassed in the war which was to come. So far as their thinking men were concerned, this war was a nation-wide conspiracy.

Further, these same people, from noble to peasant, went wild with joy when "The Day" came and war began. From the beginning they gloried in it and gloated over their seeming success. They have ceaselessly acclaimed their ruthless leaders—Hindenburg, Ludendorff, Tirpitz, and Zeppelin—and to-day they are wholly devoted to their Kaiser.

Sydney Brooks says: "Americans declare that they are not at war with the German people. The Allies know that the German rulers and their subjects are one, and that, to be at war with either, is to be at war with both."

As to the plea of their pre-war ignorance, the monograph, " German War Practices," issued by our Committee on Public Information, says: "Before the war the average number of volumes concerning war, published each year in Germany, was 700, and the majority of those written by German army officers advocated the ruthless policy of von Clausewitz, von Hartmann, and von Moltke."

And, further, any anthology—such as William Archer's "Gems of German Thought"—will show that this literary product was fairly general, and not due wholly to military authors.

It is possible to select from the pre-war writings of German pastors and professors of standing quotations showing approval of the chief elements of the German creed: their supermanhood, their right to world dominion, the wisdom of Machiavellian diplomacy, their war-worship, and the righteousness of ruthlessness in war.

Apparently the only possible plea for the German people is that they have been subjected to evil training thru long years.

Of the docility of thought, the intellectual enslavement of the German masses, there can be no doubt. These characteristics have been bred in the bone of these people by centuries of internal war, of grinding oppression by their feudal lords. Their open cannibalism from starvation, their legalized polygamy from war's depopulation —both in the seventeenth century—are historic indications of the German peasant's heritage of fear.

And for more than forty years their rulers, with devilish cunning, have utilized this fear, this mental docility, to advance their evil ends. By their system of state education—which made all teachers their tools—they have tempted every base instinct of these people—their vanity, their greed for power and wealth, their falsehood and treachery, their moral foulness.

Against this plea of evil training, several contentions may be advanced:

First.—The German people are, as a whole, unusually well educated. Their strident boasts of culture have been heard the world around. This knowledge brings with it the power of discrimination between good and evil.

Second.—Every human being has a conscience—deadened or active—to warn him of wrong-doing.

Third.—The German rulers, in tempting these people, were agents of Satan, and the devil is no more active in Germany than he is elsewhere. Conscience is the weapon against him.

Hence, with their unusual knowledge and their inherent consciences, they were well equipped to resist the evil training of their rulers—as their forefathers of 1848 did. And they had the example and the literature of the world to aid them in developing a righteous nation.

But these advantages seem to have been thrown wilfully aside, and Germany became—and is—a wholly materialistic nation, whose cult is "Might is right." As this war has so terribly shown, these people are less *im*moral than *un*moral.

All of this has a very practical bearing on the war's duration and on the character of the peace terms which should be imposed. These people believe not only that they are supermen but that only autocracy—the complete submission of the subject to his government—could have made an aggregation of weak and warring states into the great German Empire of to-day.

While they cherish these conceptions the war will go on as long as they have guns and men to fight it. The only cure for these ideas is overwhelming military defeat. Without that, revolution or a peaceful democracy seem vain hopes.

Louis Raemaekers—the Dutch cartoonist whose mordant wit has bit deep into the real meaning of this war—says: "If all the Hohenzollern dynasty should die to-day, and Scheidemann or even Liebknecht should become president of a German Republic to-morrow, it would not alter Germany. Germany is an idea. The modern German has been insistently and methodically taught that he is a superman, chosen by God to impose his will everywhere. He never doubts it. . . . The world must go on beating him over the head until he cries 'Enough!' Otherwise, the world can never live with him."

LOOKING AT GERMAN LINES — BRITISH TRENCHES NEAR BELGIAN COAST.

As to the material benefit of an autocratic government to such people as these Germans, Prof. Kuno Francke, of Harvard University—a man of German birth—denies that President Wilson is right in assuming that even the direst defeat will turn Germany from its ideals or its methods. On the contrary, he asserts that no matter how much she is humiliated and hurt by the war—no matter how great her punishment—the people will not give up their system of government by experts, and the willing submission of the subject to "the good of the state."

Apparently, what we call "Liberty" has no meaning or value to these people as a whole. On the contrary, all but a small fragment of them prefer the material benefits which an autocratic government gives. As the situation is to-day, rather than become honest and respected members of international society, they prefer their share of their "devil's bargain"—their riches, their power, their loot, their murder and rapine. If they do not change, the drafting of peace terms for their full restraint will be a very complex problem. And without such terms the "next war" they dream of will become a certainty.

PROGRESS OF THE WAR

Now let us consider briefly the present state of the war.

In this hasty review we need consider only the Western Front, since it is there that the issue will be decided, despite the collapse of Russia and Italy's titanic battles among the mountain peaks. The reason is, that it is on the west that the French, British, and American armies are fighting, and Germany must defeat those armies to win the war.

The war in the west may be divided generally into three great stages: First, the struggle of the Allies for existence; second, their fight for time to prepare; third, their slow but sure progress to victory, beginning more than a year ago.

On the map, the lower and western line shows the farthest advance of the invaders. It is a grisly trail of slaughter and destruction, stretching thru Liège, Louvain, Brussels, Namur, Lille, Amiens, and at Ligny reaching to within eighteen miles of Paris.

A month after war began, Joffre made his stand at the Marne, and the Germans were driven back to a battle line 475 miles long, stretching from the North Sea to Switzerland. This is the middle line, which was held from October, 1914, to June, 1916.

Then the long struggle of the Allies for existence and preparation was ended, and their offensive began on July 1, 1916.

As the result of this offensive on the Somme and the Ancre, and of later battles, the Germans have been forced to retire to the extreme inner line, which is the fighting front to-day.

The Allies have as yet regained but little territory. However, war maps are very transient and deceiving things. It is not the land won that counts, but the magnitude of enemy casualties. So the chief aim of the Allies has been—as they bluntly put it—"to kill Germans." The war may yet be ended by a decisive battle on the present front.

Near the northern end of the line are Ypres and the Yser River—the scene of the never-ending drives for Calais. Below it lies Cambrai—near which occurred that theoretically impossible but practically successful "Battle of the Tanks." At the elbow of the line and between La Fère and Laon is the Chemin des Dames, that "Ladies' Way" which the French won by such dogged fighting. Far to the eastward lies immortal Verdun. East of it, near Lunéville, are—according to German reports—General Pershing and his men.

There are two great battles which project monumentally above all the fighting of these three terrible years. The progress of the Allies to victory began with the Battle of the Somme, of which their later operations on the Ancre were a continuation. In this offensive the Germans were forced to yield much territory, with a loss of 570,000 men—killed, wounded, and prisoners. Further, in the four months' main offensive by the Germans against Verdun they failed with a loss of 415,000 men. In subsequent operations there they have lost 185,000 more—a total of 600,000. Thus, *in both offense and defense,* German military power, exerted to the full, was beaten.

These two operations—the Somme and Verdun—were epoch-making. The arrogant German belief was that their armies were irresistible—and Verdun showed them the falsity of that. Then they thought their lines impregnable; that—safe in their trenches in the Promised Land—they could wait until a worn-out foe gave them victory or a German peace.

BATTLE OF FLANDERS: SCENE NEAR YPRES.

But that dream faded when they were blasted from those trenches on the Somme and the Ancre by a flaming torrent of shell, fired from more and heavier guns than—with utmost effort—they could bring to bear. The mighty thunder of those French and British guns rang the knell of German military supremacy in France.

The fighting in Flanders—at the Yser and around Ypres—has been titanic and ceaseless. Its intensity is indicated by Ian Hay's diagram, which shows that, in October, 1917, the British were facing, on their 120-mile front, nearly half the German armies on the western front, with an average of 4600 enemy rifles per mile, as against 1900 on the 321-mile French front.

The Belgians hold a line, 16 miles long, from the sea southward. These heroic troops—now a well-equipped force, 200,000 strong—have not lost a foot of ground since they made their stand there in October, 1914, and rolled back the German horde from the road to Calais.

In Flanders the British, aided by the French, have gained almost complete control of the Paschendaele Ridge. Their object—like their desperate and successful battles for Vimy Ridge and Messines—has been to win the only high ground in the sector of attack.

The reason is, that observation of artillery fire is vital to success in such warfare. Now, aircraft—valuable as they are—are still of less service in observation than the full view of the field from a commanding height. The Paschendaele Ridge is 150 feet high, and from it the plains of Flanders can be seen for miles to the eastward.

This ridge is most important to the Germans for several reasons: for their hold of northern Belgium and the submarine base at Zeebrugge, and as the northern end of the Hindenburg line. Full possession of this ridge will enable the Allies to flank this line and force its defenders to fall back. It is for these reasons that the fighting there has been so desperate—that, with amazing hardihood, Allied troops have charged thru the Flanders mud and water, of any depth from ankle to waist.

The battles of the French for the Chemin des Dames had the same object. Their success brought them up from the Valley of the Aisne, and won them, in addition, the ruins of Craonne, which is one of the strongholds of the Hindenburg line.

And now a word as to that theoretically impossible "Battle of the Tanks." It was a thrust at Cambrai, which is a center of communication and hence an important strategic point. This battle smashed two things: First, all the traditions of trench warfare; second, the Hindenburg line at its strongest point—the British penetrating not only the front line, but its supporting lines for a distance of five miles.

The tactics were a stroke of genius. It was a surprise attack without preliminary bombardment. The absence of this preliminary fire not only caught the enemy napping, but freed the ground of No Man's Land from the shell holes which make infantry advance toilsome. The tanks were relied on to replace it in smashing gaps in the enemy wire entanglements.

All of this proceeded as scheduled, and their success far exceeded British expectations. They had not foreseen so great a victory. If they had had 250,000 men ready to rush thru the break in the line, the German armies would have been on the run for Belgium. As it was, the enemy swiftly massed his forces for counter-attack, and drove the British back for two miles. Tho lessened as it was, this victory is still one of the most significant in the history of this war. It showed that the German defenses could be broken at their strongest point. It was characteristic of the British to attack at just that point.

STATUS OF THE WAR

So now—after three and a half years of war—the world knows that Hindenburg's boasted "Iron Line" is breakable, and that his armies can be beaten in either attack or defense, if the Allies care to pay the price in men.

But, tho beatable, these armies are far from being beaten. On the contrary, they are still very formidable, and they are fighting savagely. So the campaign now in progress will probably see the hardest fighting of the war.

Altho the contest may be long, and is sure to be a deluge of blood, there are strong military reasons pointing clearly to the ultimate victory of the Allies, if America does her part in time.

Men.—First, take the question of men. Germany started this war with a total mobilizable force of 10,100,000 men. She has lost over 4,000,000 of her best fighters—killed, wounded, and prisoners. Excluding the possible return of the prisoners now in Russia, the German total to-day is about 6,100,000 men, and of this number her first line combatant force is 3,250,000. The remainder are men who, from age or wounds, are fit only for garrison service, for guarding communication lines, and for similar auxiliary work.

Before the recent troop movements began, Germany had on the Western Front 150 divisions, and on the Eastern Front 79. The strength of a German division has become a very variable quantity in the later phases of the war. But, taking it as 14,000, the 150 divisions in the West would amount to 2,100,000 men.

How many men will be available in the West from the 79 divisions of 1,106,000, total now on the Eastern Front, and from the prisoners in Russia is problematical. Estimates vary from 500,000 upward. Sir Auckland Geddes, Minister of National Service, stated recently in the House of Commons that the Germans would be able to withdraw 950,000 men from the Eastern Front and that the Austrians would be able to furnish enough to bring the total up to 1,600,000. The uncertain course of events in Russia might readily reduce these estimates.

However, this total and the 150 divisions in the West would make a grand total of 3,700,000 Germans there. Opposed to them are, 2,000,000 British, about 2,750,000 French, 200,000 Belgians, a small contingent of Portuguese, and a growing American army. Disregarding the Americans, the Allied forces total 4,950,000 men.

It is true that these men are not all first-line trench fighters. Some of them are artillery, engineers, and the like. But against this is the fact that the Allies, in meeting any assault by the Germans, would be on the defensive, where one man, fully supported by artillery, is worth three in the attack. Hence it seems clear that, even with Sir Auckland Geddes's estimate, the Allies would still be stronger in the West.

In any event, they have full confidence. In his annual report, Sir Douglas Haig, British Commander-in-chief on the West, says: "The additional strength which the enemy can obtain from the events in Russia and Italy already has been largely discounted. The ultimate destruction of the enemy's field forces has been brought appreciably nearer."

There is no probability that the Germans, at their maximum possible strength, can break the Allied line. Petain's immortal battle cry at Verdun: "They shall not pass!" will surely hold from the North Sea to Switzerland. But, as matters stand, the Allied forces are not sufficient for any offensive of great magnitude. It is the American army which must furnish reinforcements adequate for victory.

As to our army: All that has been announced officially is that there will be 400,000 men in France by March. On the basis of the British forces and the length of their line, these 400,000 men could hold a similarly active sector just 24 miles long. The reason is, that owing to possible casualties, there must be three or four men in reserve for every man in the trenches. So, America is perilously slow. Joseph Choate's dying injunction as to our war preparations: "For God's sake, hurry!" should be emblazoned in letters of fire above the desk of our Secretary of War. Later it may be written in blood.

Morale.—Now consider the quality of these German troops—their morale especially. The Teuton armies of to-day are not what they were in 1914. Their latest recruits are the recovered wounded, the *reformés* or men originally rejected, and some able-bodied boys of 18 or less and men of 45 or more. In a military sense, the two latter additions are boys and old men, who have little staying power under shell fire and lack fighting spirit.

It would be both unwise and unmilitary to question the brute bravery of these German troops. They have shown this quality time and again when, in massed formation, they have been driven like sheep to the slaughter. But, man for man, they are far from being the equal of Allied soldiers. And for several reasons:

They have been trained as machines, and lack initiative. They have been fighting a losing fight for three years—a condition which would sap the morale of any army. They have an inherited racial fear of the bayonet —the "cold steel"—and cry "Kamarade" when cornered. And, in some dumb way, they must realize that they are fighting for an unjust cause.

These statements are not idle boasts as to the superiority of Allied soldiery. The *élan* of French troops has filled many a brilliant page in history, and at Verdun—short, at first, of both guns and men—they showed, against the flower of the Kaiser's army, a dogged courage that amazed the world. As to the British: They hold four German prisoners to one Briton held by Germany. At Ypres, 600,000 Germans set out to break the British line and were beaten back by half their number. The British losses were 50,000; the German, at least 150,000. A captured German officer said enviously of British troops: "With such men we could go anywhere and do anything." As to our own troops of both North and South: We need only recall the memories of Gettysburg and the Wilderness. They have no superiors in any army in the world to-day.

Artillery.—The Allied armies are now superior in gun power also in the West. Germany held her overwhelming advantage in this respect for two full years—until the Battle of the Somme. Then, in both guns and ammunition, the scale swung to the Allies with accelerating speed.

The Somme and all other battles since have shown the German weakness in artillery. In their offensive last August the French had in action an average of one heavy gun for every 85 feet of the sector of attack, and a gun of some kind—heavy or light, or a trench mortar—for every 26 feet of that sector. France's supply of munitions is similarly ample. Her daily output of shell for the famous "75's"—the three-inch gun—is now 20 per cent. greater than the daily expenditure for those guns during the Somme offensive, and, for heavy guns, she is making 100,000 projectiles a day.

As to Great Britain: Working day and night, she has 100 national arsenals and 4585 government-controlled factories—all producing supplies and munitions of war. In 1917 the new national projectile factories had a total length of 15 miles. She is to-day making 575 times as many shells a week as she was in May, 1915. The British output of shells alone exceeds the German maximum—which cannot be increased while Great Britain's is increasing daily.

Tactics.—Finally, consider the nature of the later fighting—the tactics of its battles. When, three years ago, both armies dug themselves in on the Western Front, the outcome there looked like a draw—a "stalemate"—since those continuous lines of trenches could not be flanked, and the cost in lives of direct frontal attack by infantry alone would be prohibitive.

But, as the number of their guns grew, the Allies gradually evolved new tactics for this warfare. The first stage of this development began at the Battle of the Somme. It consisted of a cyclonic preliminary bombardment with unlimited quantities of huge shell. This destroyed the wire entanglements and blasted away the German trenches—rendering them untenable.

BRITISH WESTERN FRONT—CAVALRY CROSSING A TRENCH BRIDGE

A later development was the "creeping barrage" fire —a moving wall of high explosive shell which protected the slow advance of the infantry over No Man's Land.

To meet these two developments, the Germans largely abandoned their elaborate first-line trenches and shifted their men into strong outposts hidden in a chain of shell craters. This chain consisted of a series of disconnected "nests." Each nest comprised two or three craters, connected underground, protected by wire, and reinforced by timber and concrete. This change made the attack more difficult, since the advancing infantry had to charge a series of small forts. However, the preliminary bombardment accounted for many of them, and occasionally a "tank" would sit, like a motherly old hen, on the top of one of these nests until its garrison called it "Kamarade."

Then came the "pill boxes"—small monolithic concrete forts armed with machine guns—which the Germans set in geometrical patterns to a considerable depth behind their front line. These forts are so placed that each protects those adjacent by enfilading fire.

But the "pill boxes" have not stayed the Allies. If they are not shattered or overturned by preliminary shell fire, the advancing troops turn a continuous stream of machine-gun fire into the slots or port-holes for the guns of the box. Under this fire bombers crawl up to it. The firing ceases suddenly a hand grenade is hurled thru a slot—and in from two to four seconds there are only dead Germans in that concrete tomb. After all, that vaunted "German efficiency" is a pretty weak sister when real men with alert brains get after it.

Summary.—Summing up, then, we find that—despite possible reinforcement from the Eastern Front—the German military machine is crumbling, slowly falling to pieces in the West. She is outnumbered there, she is becoming progressively inferior there in guns and aircraft, and, unless the Russian developments make a change, the strategic initiative on the West has passed from her hands. She cannot tell where her lines will be attacked next, and she is compelled to face battle tactics to which she cannot reply in kind, owing to her weakness in artillery.

For more than three years on the Western Front the Germans have not won a battle—they have gone backward always. Napoleon blasphemously said: "God is on the side of the big battalions." That should be the belief of these godless Germans to-day. For their boasted efficiency—as applied to their chief industry, war making—succeeds only when they have great superiority in guns and men. Otherwise it is an exploded myth.

WHEN WILL THE WAR END?

If, then, Germany is militarily wasting away, how long can she hold out? When will the war end? That question no man may answer, since it involves a mass of considerations—military and naval, economic and psychological. A glance at the map shows just why—to-day—Germany is making a desperate drive for peace. She is eager to appear at the Peace Conference with her hands full of spoils to bargain with.

The Pan-Germany of to-day is of immense extent. Starting with the little margravate of Brandenburg, the Hohenzollerns have in 500 years succeeded in spreading their power over Central Europe and the Near East. If we add also Russian Poland, the minor countries on the Russian border, Serbia, Bosnia, and Arabia—all of which this alliance controls or claims—we have a total area of about 1,350,000 square miles. Excluding the Asiatic part, it is about 45 per cent. of the area of Europe.

As President Wilson puts it: "Germany has absolute control of Austria-Hungary, practical control of the Balkan States, control of Turkey, control of Asia Minor . . . all the way from Hamburg to Bagdad—the bulk of German power inserted into the heart of the world. If she can keep that, she has kept all that her dreams contemplated when the war began."

Just why she wishes to keep it is this: The Bagdad Railway—her dream of years—was intended to make direct rail connection from Berlin to Busrah, at the head of the Persian Gulf—not only making the countries thru which it passed German, but pointing a dagger at the heart of India.

And this was not all. This wild dream of world dominion contemplated similar connections, with similar results, between Aleppo and Cape Town, Aleppo and Peking, and, in the fulness of time, a short run for German ships across the Bay of Bengal to a chain of German naval bases on the many islands from Penang to Australia.

You see, this Bagdad Railway is the very heart of all this. But, as a writer in the *New York Evening Post* says: "Shall we continue to war for years in order to destroy Germany's control of the railway to Bagdad?"

The answer is: If we allow Germany to become a military colossus in Europe her intended dominions in the two Americas comprise virtually all of these continents except the United States and Brazil. Why this plan spared us for the time is not clear. Perhaps a huge indemnity would suffice until Germany was ready to take us over.

In any event, it is quite clear that, if we do not concern ourselves with the international politics of Europe, those politics—and, so far as Germany goes, their fleets and armies—will concern themselves with us. The United States is no longer isolated. This Republic is a great world power.

So there should be no compromise that would permit Germany to cherish even the wan shadow of her dream of world dominion—a dream which, to us and to our Allies, means world despair. To the hazy doctrinaires and pacifists who advocate their so-called "magnanimity" in this respect I commend the noble words of Abraham Lincoln when, shortly before the close of the Civil War, he was asked to compromise in the interests of peace. In refusing and insisting on a military decision, he said: "The fiery trial thru which we pass will light us down, in honor or dishonor, to the latest generation. We—even we here—hold the power and bear the responsibility. We shall nobly save, or meanly lose, the last, best hope of earth."

So the war must go on to—for Germany—its bitter end. The contest will be titanic. For Germany, tho outnumbered, has yet a huge force remaining. Further, she has the advantage of position, in fighting on the defensive in a central location from which she can strike at any front. To balance this advantage, the Allies should be able to press simultaneously on all fronts, and the collapse of Russia prevents this. Again, to win a decisive victory, the numerical superiority of the Allies should be much greater than it is. On the contrary, France has reached the zenith of her man-power, Great Britain is nearing her maximum, and both are suffering constant losses. And strong reinforcements from America will be appallingly slow in coming. These pacifists of ours, who forced a two-years' delay in our war preparations, have cost the Allies, and will cost us, millions of lives, billions of dollars, and untold suffering.

Finally, altho Germany is very hungry now, her armies cannot be starved into submission. They are fed while the people suffer. The Kaiser is fighting for his throne and his autocracy for its privileges. So the last man who will fight for them must die before they yield. Hence, in their slow defeat, their armies may yet—fighting desperately—fall back on German soil.

Once there, the military problem of the Allies would become much more difficult. For, since the war began, Germany's Franco-Belgian frontier has been greatly strengthened, so that now it bristles with guns. And back of it lie the two great strongholds, Metz and Diedenhofen, with, in their rear, a chain of huge fortresses from Strassburg to Cologne, along the Valley of the Rhine. Despite the destruction of the fortifications of Liège, Namur, and Maubeuge, the day of the fort in war has not passed, as Verdun has shown. It is an immense support for armies in the field.

However, in all this there is no ground for pessimism. It is darkest before dawn. The military situation now is far better than it was six months before the end of the Civil War. And at that time the air of the North was blue with pessimism and, to weak-hearted men, dark with despair. There was so much of this that even Lincoln—whose faith never faltered—doubted his own reëlection, or, indeed, that of any other Republican.

Besides, there were three kinds of victory to be won in this war, and the Allies have won two of the three already. The first of these was the moral victory, and Germany has been condemned in the high court of the world's opinion. The second is the economic victory, and Germany is now financially a ruined nation. Her wealth for war-making came very largely from manufactures, exports, and sea-borne trade. Albert Ballin,* the leader of Germany's shipping enterprises, says: "Do our fools of Chauvinists realize that we have hardly a port at which our ships can call and where a friendly welcome will be extended to them? Dover, Falmouth, and Southampton; Gibraltar, Malta, and Alexandria; Aden, the Persian Gulf, Bombay, and Colombo; Singapore and Hong Kong—what are they? Great Britain's arsenals, naval bases, coaling stations, repairing docks, in which we dare not show our faces, if Britain so wills. It is the same around the African continent, the same in the West Indies and the Pacific. We have not a coaling station of our own, not a place where we can effect repairs. . . .

"With a hostile British Empire . . . how are we to procure the raw materials which that Empire alone can supply? . . . Where are we to procure our supplies of jute, if not from India? If we are driven from Africa, where are we to seek our full supplies of rubber, palm kernels, and copra? . . . Wool from South Africa and Australia, spelter, wolfram, nickel, cobalt, and endless more? . . . And all the military victories and all the wild will-o'-the-wisps about 'Hamburg to Bagdad' will not help us."

It is regrettable that there are not more people like Herr Ballin in Germany. Our National Chamber of Commerce has already suggested to business men a virtual boycott of Germany with regard to business in the United States after peace comes, unless she abandons wholly her "blood and iron" method of obtaining foreign business, as in this war. So, in any event, the economic victory may be taken as won.

There remains still the military victory, which is far more important now than Germany's economic ruin as a means of keeping her from gaining wealth with which to wage future wars.

That military victory is, in the end, assured by the great preponderance of the Allies and this country in man-power, wealth, and resources. But the time when that victory will be achieved depends now on America, and fundamentally on the speed with which our war organization in Washington works. For in every battle—military or naval—assuming equal skill—it is the preponderance, the excess, of guns and men which is the winning factor. The preponderance of the Allies is now too small for decisive victory. America must throw two million—perhaps five million—men into the scale of battle.

Then—with sufficient superiority in men, with a vast air fleet to strike at Krupp's works, the heart of German military strength, and with the American embargo gravely lessening German food supply—the war's end should not be far away.

WHAT SEA POWER HAS DONE

Let me now point out what sea power has done in staying the dark tidal wave of war. It is true that misuse of one of the legitimate weapons of that power—the submarine—has produced the present grave conditions, as to the transport of troops, munitions, and food to Allied countries. But submarine strength alone is not true sea power. Surface command of the sea is all that counts in the end.

And now for the true sea power—what has it done? For the answer, turn to the battle lines of France. The invaders were stopped at the Marne by Marshal Joffre—one of those splendid, towering figures who appear always in world crises. But in the woeful slaughter of the months that followed, in the steady wearing away of her military strength, France—without Allied aid—would have gone down in defeat before that horde of Huns. And that aid—coming in full tide from England, her colonies and dominions, from India and Algiers—was made possible only by the "gray, storm-beaten ships" of the British fleet, grimly guarding Germany's imprisoned navy.

And that aid and guard have been continuous. Since war began, Allied merchant ships have transported 13,000,000 troops 25,000,000 tons of explosives and supplies, and 51,000,000 tons of coal. These, with other shipments, make a total of 130,000,000 tons carried across the seas during that period.

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* Since its appearance, the authority of Herr Ballin's letter has been questioned. However, the quotation gives the actual conditions after the war closes.

And much, if not all, of this vital sea-borne trade would have been impossible if the German high-seas fleet had been loose. The British grand fleet thus has been the very keystone of Allied success in this war. And this is not all. If that fleet had been too weak for this watch and ward, England—with its feeble army of those early days—would have been invaded at once. With her naval bases seized, her fleet would have been homeless and helpless.

And, then, in Winston Churchill's words, it would have been "Your turn next!" for America. Long ago our shores, from Maine to the Chesapeake, would have been seized, our eastern cities would now be occupied, and to-night there would be German troops in Philadelphia. This Republic may well thank God for the British fleet!

OUR BATTLE FLEET

And now to turn to a far more pleasing story—that of our Navy, the gallant service on whose history the deeds of John Paul Jones, of Stephen Decatur, of Farragut and Dewey, have shed unfading lustre. Before discussing the Navy's probable work in this war, let me explain a few points as to the ships which will serve in that work.

There are five classes of fighting ships in a modern fleet: *First,* the battleships—huge vessels of moderate speed, built to give and take the hardest blows. The *Pennsylvania,* a vessel of 31,400 tons, carries twelve 14-inch guns. She is capable of meeting any vessel afloat to-day. We have now at least twenty-seven of these vessels—built, building, and authorized.

Second, the battle cruisers, which are modified battleships, having much higher speed but fewer guns and thinner armor. They are larger and faster than any ships of their type in the world—having a displacement of 34,800 tons, a speed of 35 knots, and a main battery of ten 14-inch guns. The battle cruiser will be linked for all time with the name of Sir David Beatty, that most able and fearless British Admiral who, at the Battle of Jutland, bore the brunt of the attack of the German high-seas fleet.

In that battle—lasting about six hours—$150,000,000 worth of ships were sunk and 9000 men died. Beatty's Squadron, headed by his Flagship *Lion,* led it into action. He lost three of his ships—among them the *Queen Mary,* the noblest vessel then afloat. Struck by a shell on her turret-top, she sank like a sounding lead, carrying a thousand men to death. Her magazine had exploded. You know, a warship is not only a floating battery, but a possible volcano owing to her cargo of high explosives.

The third of a fleet's fighting ships is the scout cruiser. These are lightly armed and armored vessels of very high speed, designed for reconnoitering. They are the cavalry of the sea, always seeking the enemy, generally finding him, and keeping the German program from proceeding "as scheduled."

Vessels like these scout cruisers had a brush with the enemy the other day off the Bight of Heligoland. They are incessantly at that sort of thing. From the beginning of the war they have been trouble-breeders for Germany. They are ships of about 3500 tons and 35 knots speed.

The fourth of the fleet's fighters is the destroyer. These vessels are small, handy, and exceedingly swift craft whose main weapon is the torpedo discharged from tubes on deck. They rank next to battleships in fighting value. So, as Count von Reventlow, the vociferous German naval critic, says feelingly, "The destroyer is the submarine's worst enemy!"

The last of its fighting ships is—as it should be—the abhorrent submarine, the sneaking assassin of the deep. Farragut once said that the torpedo was not a gentleman's weapon—and, doubtless, the great body of blue-water sailors in allied navies to-day echo, as to the submarine, the great admiral's scornful words. German opinion differs, but, to the blood-stained degenerates who run their U-boats, the ancient chivalry of the sea has no meaning.

OUR NAVY IN THIS WAR

What will our Navy do in this war? The answer is that, altho our huge dreadnoughts may never fire a gun, the Navy's work in a prolonged war will be both widespread and hazardous, taxing to the limit the energies of the 300,000 officers and men now in our sea forces.

The first duty of the Navy is to protect our own coast, but the danger of hostile attack there is remote so long as Great Britain is the jailer of Germany's high-seas fleet. An invading fleet would have to take one of four lines of approach to our coast: either from the Orkneys, the English Channel, Gibraltar, or some point on the African coast, as Agadir. Now, on these four lines, the distances range between 2800 and 4200 miles, while the steaming radius of a modern fleet is about 2000 miles—that is, it can steam that distance, fight a battle, and then return to its base.

Evidently, then, for successful operations, the German fleet would have to seize a base on or near our coast. In doing this it would be opposed not only by our fleet but by a pursuing British force, and, as well, by such mobile army as we had available. It is clear that the task would be too great, even for Germany. Our coast is hence wholly safe from invasion, providing we and our Allies win this war.

There is, of course, the possibility that one or more battle cruisers might slip past the British blockade and dash across the Atlantic to give America a taste of German frightfulness by firing a few broadsides into New York. But this would be madness, for they would never get home again. And there are other prohibitive reasons.

In the first place, Germany has no battle cruisers to spare. The few she has she needs sorely for the coming naval Armageddon in the North Sea. Second, in the shallow fringes of that sea the forbidden area mined by the British is very large and still growing. Third, across the northern boundary of the sea, from the Shetlands to the coastal waters of Norway, there is a close blockade, backed by an enormous dreadnought fleet.

So, while a disguised raider, hugging the Norwegian coast, might slip thru at night or in a fog, a huge battle cruiser could scarcely escape notice and instant pursuit by swift ships of her own class.

From time to time, also, we hear that Germany intends to make submarine attack on our coastwise commerce and on ocean liners near our ports. This is improbable, since the undersea boats find their prey thickest in British waters. However, if they should come, we have a fair force of cruisers, destroyers, and submarine chasers to meet them. And, in any event, the submarine menace seems on the wane.

It is, however, quite possible that submarine mine layers might come to our coast. Admiral Jellicoe has given our Navy Department official warning as to this. These boats carry about thirty mines each, and they have dumped their cargoes all about the British islands. Floating mines can, of course, be strewn in any waters, and, from Cape Cod southward, the bottom slopes so gradually that anchored mines could be planted for many miles to seaward. In view of this, we have now a considerable force of mine-sweepers ready for service.

But the most extensive and most hazardous work confronting our Navy is that of keeping open our communications with Europe—convoying merchant ships across the Atlantic and through the forbidden zone which Germany has drawn about the British islands. For this duty only swift cruisers and destroyers will serve. At present, we have about 22 of the former and 60 of the latter, some of which are in European waters. However, by next spring our destroyer flotillas will begin to grow, and so rapidly that, by the end of the year, we shall have a greater force of these vessels than any other navy. So, if the submarine menace does not pass away, we shall be able to meet it.

THE "WET TRIANGLE"

From time to time we hear in the press from civilian "experts" a demand that the Allied fleets shall make a combined attack on the German fleet and the German naval bases on the North and Baltic seas.

These critics of Admiral Beatty and the British Naval Staff should learn something of modern sea fighting—especially the attack on fortified ports—before venturing to write on such a subject. Let me commend to them the dictum of that master of naval strategy, the late Admiral Mahan, who said: "Unless you have ships to burn, a match between ships and forts is unequal." The wisdom of this was shown conspicuously by the disastrous attempt of the Allied fleets to force the Dardanelles.

As a matter of fact, such an attempt—even on the North Sea bases only—would be suicidal for a dreadnought fleet. For, the whole of the German North Sea coast is a mass of islands and mud flats, the bottom sloping down very gradually to the ten-fathom line which passes thru Heligoland. Within that line, and with the bottom containing many shifting shoals, it is risky even in time of peace for deep-draught vessels to pass thru much of the area except thru regularly dredged and buoyed channels.

Again, the whole Bight (Bay) of Heligoland is thickly mined, the channels thru the fields being known only to the Germans. In the recent action near the Bight the British scout cruisers could only go within thirty miles of the island. Further, the whole coast is defended, not only by forts and batteries but by concealed guns of the most powerful type and by subterranean stations for launching torpedoes.

Further, the mouth of the Kiel Canal lies about six miles up the Elbe River from Cuxhaven. The guns of Cuxhaven have a range of five miles seaward, and the navigable channel from the sea up the river is only two-thirds of a mile wide, with every foot of it dominated by heavy guns.

And, again, Heligoland, Wilhelmshaven, and Cuxhaven are only about forty miles—or less—apart in this "Wet Triangle." Hence, none of these fortresses can be isolated. None of the three can be attacked without receiving prompt aid from the submarines and guns of the other two. And the guns of these fortresses are so mounted as to be capable of plunging fire on a ship's deck which is not protected by heavy armor. One such hit would go far toward wrecking the heaviest dreadnought ever built.

And, finally, the whole area of the Triangle has been plotted in squares on the German artillery maps, with the range of each square known, and the guns would be fired in groups or salvoes, so that a ship in any given square would have no chance of escape.

There is unquestionably no better guarded section of coast line in the world than the shores of the "Wet Triangle." It can be attacked with success only from the air.

The fact that the British monitors bombarding the Belgian coast fire at ranges from 12 to 18 miles and from behind smoke screens shows how seamen fear shore batteries. And to the fire of these batteries in this case would be added that of the whole German fleet lying safe behind its shore defenses.

In view of all this, Germany would like nothing better than to have some foolhardy admiral, forced by the public demand, steam into sure death in the "Wet Triangle."

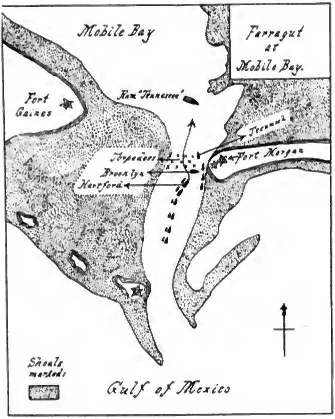
FARRAGUT AT MOBILE

In arguing for the advisability of this act of military madness, these civilian critics make much of Farragut's one historic oath—his "Damn the torpedoes!" uttered at

Mobile Bay. The circumstances there give no warrant for their contention. Farragut was not foolhardy there. He was forced by the danger of his fleet to be wisely daring.

The entrance to the bay was guarded by Fort Morgan on one side and a triple row of "torpedoes" (mines) on the other, the distance between being but 100 yards wide and at the most deadly range from the fort. Forty-six of the torpedoes were made of beer kegs and 134 of them of tin. All were fitted with percussion fuses. A short distance from the entrance lay the ram *Tennessee*, a heavy casemated ironclad, the most formidable vessel ever built by the Confederacy.

Farragut's fleet consisted of four light-draught monitors in advance and six heavy wooden ships following, each of the latter having a smaller vessel on its port side. The *Brooklyn* led the column of wooden ships, the flagship *Hartford* being next in line.


Farragut at Mobile Bay.

The *Tecumseh*, the leading monitor, struck a torpedo and went down like a sounding lead. Then the *Brooklyn* sighted some floats marking a nest of torpedoes just ahead. She was at once stopped and backed, thus lying across the narrow channel and blocking the advance of the ships behind her. This held the *Hartford* especially where "the shots from the enemy turned her deck into a slaughter pen, so that blood ran in streams from her scuppers."

Farragut hailed the *Brooklyn*, asking the trouble. The answer was "Torpedoes."

"Damn the torpedoes!" he shouted. "Follow me!" And, swinging to port, he went at full speed over the torpedoes directly toward the *Tennessee*. The torpedo cases were heard striking the *Hartford's* coppered bottom; their primers snapped, but none exploded.

In his official report of the battle, Admiral Farragut said, as to the torpedoes: "We had been assured by refugees, deserters, and others of their existence, but, believing that, from their having been some time in the water, they were probably innocuous, I determined to take the chance of their explosion."

From these circumstances, you see that Farragut had three alternatives: either to withdraw his fleet and give up the attack; or to suffer his flagship to be destroyed by the guns of the fort as he struggled thru; or to charge over torpedoes which he judged might be rusted and inactive.

Wisely daring, he chose the last of the three. But his action was a very different thing from deliberately leading his fleet into mine-fields that he knew to be both active and appallingly destructive.

WHAT OUR ALLIES HAVE DONE

And now let us turn a moment to what our Allies have done in this war—to their vast service to mankind, their sorrowful sacrifice in the graves that crowd all Europe.

Belgium needs none to speak for her. "The Lion of Brabant" won deathless fame when unafraid, he faced—and for two weeks held—the huge horde from beyond the Rhine. For honor, the martyred kingdom gave her all. Desolate she may be now—but never in despair. And the dawn of her new day of peace seems almost breaking.

And, then, on France, for two full years, fell the brunt of that fierce onslaught, while England was gathering her land forces. The silent, fearless, steadfast way in which she met it has stirred the ceaseless admiration of the world. There is a touching story of a young French officer which tells the reason why. Asked for what he was fighting, he lifted a piece of the sod on which he stood and, kissing it passionately, he said: "For France! For France!" In all earthly things, there is but one creed in France, and that is "La Patrie."

And she has made gigantic sacrifices for that creed. Holding more than two-thirds of the Western Front, she has had 3,875,000 casualties in her armies. All France is studded with the white crosses of her dead, and her hopelessly maimed are everywhere. Seven thousand square miles of her territory are still in German hands, its population enslaved, its wealth looted, and its lands and buildings sure of devastation and destruction if the Germans have the time. This territory, too, before the war, produced two-thirds of France's coal supply and has an iron-ore reserve greater than even Germany's in Lorraine. From the beginning of the war until August 1, 1917, France has expended about $16,930,000,000.

And now—after all this—France is weary beyond words, and looks eagerly to the great Republic of the West to fulfil swiftly General Pershing's words when, stooping over Lafayette's grave, he said softly, "Lafayette, we have come!" It was the promise of relief for their war-worn men that made women in Paris kneel in homage when our flag, borne by our troops, passed by.

On England's giant shoulders now is laid the chief burden of the war until unready America shall do her share. Britain's part has already been colossal. Under her agreement with France she was required only to guard the seas and to furnish 100,000 men. Instead, she doubled her fleet and sent 2,000,000 men to France.

The story of that first expeditionary force of about 85,000 men is one of the saddest and noblest in all history. The bulk of it sleeps to-day in quiet graves in France or, maimed and blind, is guarded in England's gentle homes. It was outnumbered five to one when it first met the Germans at Mons in Belgium. Fighting desperately, it fell back slowly until the Marne was reached. There the retreat ended, never to begin again; for it flung its then feeble strength into the attack with the troops of France, and, for the first time since the days of the great Napoleon, a Prussian army was turned and driven back.

The story of the soldiers of Great Britain and her Dominions thruout this war is one of dogged courage and brilliant dash. I have time for only a few instances: "General Smith-Dorien's army of 37,000 men lost 10,000 in August, 1915, 10,000 in November, and 5000 in October. . . . The Seventh Division of 18,000 men was reduced in three weeks . . . to 233. . . . One regiment alone, the Coldstream Guards, has been wiped out and reconstituted no less than twenty-one times since the war began."

And—with her little regular army thus wiped out—this sacrifice was that of eager volunteers. Conscription—instead of providing the bulk of Great Britain's army—had, in February, 1916, added only about 750,000 men to it. Before that there had been 4,250,000 volunteers. And—as with us—these were the very flower of British manhood. Kipling's "flanneled oafs of the wickets" left their universities, their clubs, their drawing-rooms, and died for England's sake. The losses of British armies—the killed or permanently disabled—in the first three years of the war were about one million. Great Britain has now 3,000,000 men serving on all fronts. Besides these, there are 2,000,000 in reserve in the British islands, and nearly another million on garrison duty thruout the Empire.

The total number of British women workers in the war was, in 1917, considerably over 5,000,000. From 60 to 80 per cent. of the machine work on shells, fuses, and trench warfare supplies is now done by women. There are 183 separate gauging operations on each 18-pounder shell, much of which is done by women.

The population of the United States is now 103,000,000, that of Great Britain is 48,000,000. Hence, to equal the British Empire's colossal achievement as to human war material, we shall have to raise an army of between 9,000,000 and 10,000,000 and enlist 10,000,000 women in war industries.

OUR WAR PREPARATIONS

Our war preparations are too well known to be recounted in detail here. Briefly, we have now an army of 1,500,000 men in France and in training, and 300,000 men in the Navy—which is twice the size of the British Navy before the war began. We have more than 1000 naval vessels in commission and are building the greatest force of destroyers ever known. The largest merchant shipbuilding program in the world's history is also now under way. And we are building a vast fleet of aircraft and training its aviators. All of this immense work has been planned and started with a speed unknown in any national history. The question is only: Will it be done in time?

In this country there is, with many, a curious prejudice against any criticism of the Administration or its war organization in the conduct of war. This prejudice must seem inexplicable to Lloyd-George and Clemenceau. It would have brought a humorous smile to the worn face of Abraham Lincoln, who was deluged with criticism, and would have made McKinley laugh, in view of his experience during the Spanish-American War.

There are two classes of criticism: the destructive kind, which is mere partisan or malicious carping, with no suggestion of remedial action. This sort of thing has nothing to commend it. On the other hand, constructive criticism—pointing out an evil and calling for its removal—is of the highest value to those who are doing any work, war-making included. So the little I may say in comment on our war preparations will be constructive criticism purely.

First: let me note that this war is a war of the people, for the people, and by the people. It is not a partisan nor an Administration war. We, the people, must pay its enormous cost in money and its far more onerous cost in human life. Those troubled homes to-night—with their blue-starred flags flying proudly—will pay in grief and tears the saddest taxes of this war. To lighten their burden, to keep the life-loss low as may be, is the first duty of our statesmen, their solemn responsibility in this war.

Manifestly, to do this we should have the ablest brains in this country operating our war organization. There should be, first of all, a coalition cabinet, enlisting men of international fame among our political leaders, our captains of industry and commerce. Lincoln included in his Cabinet his chief rivals for the presidency and even a member from a slave-holding state. The Cabinet of to-day must face those masters of the art of war—Ludendorff and Mackensen, Tirpitz and Capelle.

Again, in some conspicuous instance our war preparations seem to be in the hands of amateurs. Fuel administration, for example, is a purely technical matter, requiring an engineer of the first rank.

Further, take the Shipping Board. From the beginning its ruling members have been men untrained in naval architecture, shipbuilding, and marine engineering—the sciences vital to speedy success. From press reports, it seems to be at last under way, altho we must await results to prove this. Finally, the censorship should be so slackened as to give the people full information as to war preparations and events which—if made public—will not give the enemy aid. Congress, in its recent investigations, has done a work of the greatest public service. Even in a democracy officials fully shielded by the censor may become autocrats.

Abraham Lincoln said: "The United States will last forever, unless it commits suicide." In this, the greatest conflict of all time, war-making by amateurs is a very facile means of self-destruction.

WHAT ARE WE FIGHTING FOR?

What are we fighting for? Why should our men die in Europe's battles?

If those questions are asked by honest seekers for information, they deserve full consideration. If, on the contrary, they come from pro-German sympathizers, pacifists, or advocates of an early and inconclusive peace, they are a close approach to treason.

PALESTINE FRONT—RED CROSS SLEDGES FOR THE WOUNDED.

The reason is, that we must either "Go on or go under" in this war; that those who are not with us are against us; that we have two sets of enemies: the Teuton armies beyond the sea, and the "Hun within our gates." And these foes within our household—notably in their continuous drive for a German peace—are perhaps America's most formidable enemies to-day.

Any public talk or newspaper articles advocating peace without conclusive military victory encourage the enemy to prolong the war, in the belief that this Republic is in it half-heartedly. And any prolongation of this war means the death of more Allied troops—our men among them—in No Man's Land and on the sea. The price of the liberty given these men to wag their tongues and drive their pens is thus the blood of our nearest and dearest.

We find these men in all grades of society—senators and ex-senators of the United States have been among them, the president-emeritus of a time-honored university, the proprietor of a great chain of newspapers, college professors and their sons, and so on to the ragged soap-box orator in the slums.

Elihu Root said that there were some men walking the streets of New York who should be shot at sunrise. William J. Flynn—until recently Chief of the United States Secret Service—says that there are at least 250,000 German spies, sympathizers, and pacifist pro-German workers in this country to-day. And, from what I know of conditions in New York, I judge his estimate to be very moderate.

But to return to our question: What are we fighting for?

There are several answers to this question. The first is this: The United States has suffered intolerable wrongs from the German Empire, beginning before the sinking of the *Lusitania* and continuing until the declaration of a state of war. American ships were destroyed and American lives taken on the sea. An elaborate spy system was maintained by the German Ambassador. It is estimated that $27,000,000 of German money was spent in propaganda here. Mexico and Japan were invited to make joint war on this country.

Our munition plants were destroyed or endangered. There has been an estimated loss of fifty million dollars from the attacks on these and other establishments. Sedition was spread among our workmen. Our growing crops were threatened. And so on, thru a long list of crimes involving treason, murder, arson, and piracy.

That is one answer. But, there is another which is stronger still. It is this: Nearly all that is worth while among mankind in Europe has "fallen among thieves" and murderers during these terrible years, and this Republic can no longer "pass by on the other side"; it can no longer stand aloof.

Look at Belgium! Fenced in by death-dealing electric wires, the slow martyrdom of that hapless kingdom goes on—its men enslaved, its women in conditions worse than death, its little children dying of hunger and cold. And the German Government will—if not balked—keep that whole people as a nation of slaves in the very heart of Europe, or, worse still, will exterminate them. When asked by Minister Whitlock what he would do if England and France stopped feeding the Belgians, Governor General von Bissing said: "Starvation will grip those people in thirty to sixty days. It is a compelling force, and we could use that force to compel the Belgian workmen . . . to go into Germany. . . . The weak remaining, the old and the young, we would concentrate opposite the firing line, put firing squads back of them, and force them thru that line."

The situation of Serbia is worse still. From the beginning it was the purpose of the Central Powers to wipe out that little people, since it barred the realization of the Mitteleuropa dream. In their woful migration, a pitying

God acting thru Essad Pasha, an Albanian brigand chief—saved the wan wraith of what was once a nation. But one-fourth of it is dead, and ten thousand of its young girls have been sent into Turkish harems.

The story of Poland is too long, too sorrowful, to tell. The atrocities there and in Roumania and Montenegro were the work of human devils. Germany's record with all of these feeble peoples is one of pitiless ferocity, of systematized bestiality.

So far I have spoken of men and nations only. But what of womankind? Of the agony and shame suffered by the women of those conquered lands I may speak only with bated breath. When this war closes, its most pitiable victims will be, not the silent dead who fell for their country's flag, nor the maimed veterans whose wounds will be their badge of honor, but the multitude of sad-eyed women, of desolate young girls, on whose tortured innocence have been set the foul stigmata of the most bestial nation that—since the days of Sodom—has polluted God's green earth.

The details are too hideous to recount. A great mass of them are embodied in British, French, Belgian, and other official reports, which will be made public at the close of the war. Dr. William T. Hornaday, of New York, says: "To-day the American people as a mass do not know more than one-hundredth part of the crimes of Germany. . . . It takes strong nerves to go thru these thousands of pages of printed documents, and scores of ghastly pictures, without becoming thoroly shaken."

And what of the helpless little ones?—that host of baby dead who now "are mightier far than the whole of the German Empire, for, until the Trump of Doom, they will be waiting at the bar of God?"

I have told you of the twenty-one children who froze and starved to death every day last winter in Brussels. In that terrible march across the Albanian mountains 23,000 little Serbian schoolboys drifted to death amid the snows.

Catharine Van Dyke tells of a tragic God's-acre she saw near Chauny, in the north of France. There are 200 tiny mounds there, each bearing a white cross with the legend, "Here lies a child of France." These children died from suffering during deportation or from the abuse of German soldiers. Miss Van Dyke says: "Many were picked from the ditches with their tiny arms outstretched, still appealing to their mothers. Our boys say that so they buried them. In all the rain and darkness their baby arms are still outstretched."

In writing of the great Hindenburg drive in Poland, Frederick C. Walcott says: "A million people were driven from their homes. Half of them perished by the roadside. . . . Wicker baskets—the little basket in which the baby swings from the rafters in every peasant home—were scattered along the way, hundred and hundreds until one could not count them, each one telling a death."

Dr. Martin Niepage, a teacher at the German Technical School at Aleppo, says: "The German Consul at Mosul said in my presence at the German Club at Aleppo that he had seen so many children's hands lying hacked off on his way from Mosul to Aleppo that one could have paved the road with them." Referring generally to such atrocities, Doctor Niepage says: "'That is the teaching of the Germans,' says the simple Turk, when asked about the authors of these measures."

This ghastly and ever-growing record of outrage and murder is another answer to the question: "What are we fighting for?"

The Christ of Gethsemane, of Calvary, died for mankind—not for the little lives of men, but for their deathless souls. And surely these men of ours—made in the image of their Maker—who go clear-eyed and brave to battle now, could have no nobler mission than to fight for—and, if need be, die for—that invisible flag streaming high above those far-flung battle lines, the Broad Standard of Mankind!

It is for these reasons, in part, that America goes to war. But there is another reason that is stronger still—that strikes more closely home. It is this: If we do not swiftly join the massed forces of civilization with every ounce of our available strength, *Germany will win.* And then we—single-handed—shall have to fight a military colossus, a leviathan of the seas, grown fat and gross on the booty, the blood, and tears of ravaged Europe. So, not only for Europe's sake, but to keep from our own shores these victorious armies, our men face them to-day.

"It is more precious that America should live than that we Americans should live," says Secretary Lane. And to save that America—its honor, its ideals—to stand side by side with that old motherland of ours, with wan and wounded France, in stopping the hideous sacrifice of gallant men, of the honor of gentle women, of the lives of little children, the American flag has sailed beyond the sea on its high emprise in those distant fields of blood.

And so, when "to drum-beat and heartbeat" our lads go marching by, let a smile of pride break, like an April sun, thru our mist of tears. For, in honor, they can do no other.

Pray that—if God will—they may come home to us again. But, if that may not be, we shall know that in their stern fight they have kept the faith; that the honor of America was safe in those pale, rigid hands. And wherever they may lie—in dark ocean depths or on some green hill far away—they will be "wrapped in their country's glory, put to sleep in its flag."

COAL THRIFT

IN view of the existing coal shortage and the consequent urgent necessity for economy in the use of fuel for domestic heating, it becomes the patriotic duty of every citizen to study and to practice all the possible ways and means for helping in this work. The fact that a man may have an ample coal supply, or that he may be so well to do financially as not to need to practice economy in the use of fuel, does not relieve him of the duty he owes to the public to save, that others may not suffer by his negligence. In order to aid in the present situation, the "*Committee on Fuel Conservation*" of the *Engineers' Club of Philadelphia* offers the following suggestions:

ELIMINATE UNNECESSARY HEATING

1. *Reduce living quarters to a minimum.* Close off unused rooms, and shut off registers and radiators (except in case of hot-water heating systems, in which the closing of radiator valves may stop the circulation in the radiators to such an extent as to allow them to freeze). Freezing of hot-water radiators when the valves are shut off may be prevented by covering the radiator with a blanket or specially constructed hood.

2. *Close off rooms communicating with sleeping-rooms,* which are ventilated at night by open windows, to prevent the chilling of more space than necessary.

3. *Discontinue heating of garages* which are not used as living quarters. If the garage is heated by a hot-water system, a slow fire, sufficient only to prevent freezing, should be maintained. Non-freezing fluids can be used in radiators of cars, or freezing can be prevented by small gas heaters, or by an electric light placed under the hood, the hood and radiator being well covered by blankets.

4. *Close up tightly all outside openings* into cellars and basements. Replace any broken window panes, and chink up all cracks in walls and floors and around door and window frames. Sufficient ventilation during the day will usually be secured in the necessary opening and closing of outside doors and thru crevices under doors and about the window sash. Hot-air heating systems insure good ventilation, but defective heaters are apt to leak gas and render the air in the house unfit to breathe.

5. *Have windows and doors weatherstripped* if possible. Storm sashes are advised for windows on north and east side of house, these sashes being hinged at the top, so that they can be opened at night, or when necessary to secure ventilation.

6. *Provide yourself with a reliable thermometer* and keep house heated to a mean temperature not exceeding 70° (thermometer placed at a height of 5 feet above floor), unless there are old people in the house who require warmer quarters. A uniform house temperature is most desirable, not only for comfort but as a means of economy. To insure uniform heating, fires should be attended to regularly, intelligently, and systematically.

7. *Small families can sometimes save in fuel bills by using gas* or kerosene ranges instead of coal stoves for cooking. The coal range will, however, be cheaper when it serves as a means for heating a part of the house, as well as for cooking. The fireless cooker will, in many instances, prove effective in saving fuel bills.

8. *Heating requirements may be further reduced* by (*a*) pulling down shades at dusk, (*b*) allowing sun to shine in rooms during the day, (*c*) keeping the air in rooms moist, by placing pans filled with water on stoves and steam radiators, and (*d*) by checking fire when occupants of house go out.

PUT HEATING APPARATUS IN ORDER

9. *Thoroly examine your heating apparatus,* and see to it that it is in first-class condition. If you have any doubt about it, call in a reputable heater man or heating specialist, and promptly act on his advice.

10. *See that your furnace or boiler is clean* and the grate in good condition. Make sure the smoke-pipe and chimney flue are not choked up with soot.

11. *See that smoke-pipe is provided with a "turn damper" and a hinged "check damper"* for regulating the draft. A wire or chain should be attached to the check damper and led up through the floor above so that the draft can be regulated by hand or by some automatic means, without the necessity of going to the cellar.

12. *In the case of hot-air heating systems,* see that all your pipes, from the heater to the wall flues, are tight and uniformly pitched. The pipes should be well covered with asbestos to prevent loss of heat, unless heat is required in the cellar to properly warm the floor above. Pipes supplying air to rooms not in use should have dampers closed off. See that the cold-air pipe to the heater is intact, tight, of ample size, and clear of obstructions, and that the air is taken from a point outside where wholesome air will be obtained and where the winter winds will accelerate, and not retard, the flow of air into the pipe and thru the heater. In some cases where the heater is too small, it may be necessary, in cold weather, to take a portion of the air supply from the cellar.

13. *If gas leaks from the furnace* into the air space, have the heater repaired, and if it cannot be properly repaired, have it replaced before the next heating season. Many old-style heaters now in use are very inefficient, and produce a most unhealthy atmosphere in the rooms, particularly when the draft is checked.

14. *See that the water-pan is in place,* and keep it filled with water.

15. *In the case of hot-water and steam heating systems,* see that the boiler and the pipes in the cellar are well covered, to prevent loss of heat. The boiler should be covered with a gas-tight magnesia plastic covering not less than 1½ inches thick, and the supply and return lines should be protected by standard thickness magnesia, or other good pipe covering material. Make sure the baffle dampers inside of heater are adjusted, so that the gases will not short-circuit to the chimney.

16. *See that fire doors and ash pit and cleaning doors fit up tightly* when closed. It is usually advisable to plaster around cleaning doors with magnesia plastic to prevent ingress of air when the draft is on, and the escape of gas from the heater when the draft is checked. Material for this purpose is cheap and can be obtained from any pipe-covering establishment.

USE SUITABLE SIZE OF COAL, IF OBTAINABLE

17. Since little else but anthracite fuel is used for domestic purposes in Philadelphia and vicinity, the suggestions made below regarding coal sizes and methods of firing will apply chiefly to this class of fuel. All domestic sizes of anthracite coal have practically the same heat value. Certain sizes are, however, better adapted to given purposes and conditions than other sizes.

18. *Egg and stove coal are best suited for large furnaces* which are fired infrequently, say at intervals of six to twelve hours. Egg coal is somewhat cheaper than the stove size, and is adapted to furnaces in which a deep bed of fire can be carried, say 10 inches to 15 inches. Unless a deep bed of fire is maintained, the stove size will prove more economical than the egg.

19. *Chestnut and pea sizes are used mostly for ranges,* laundry stoves, and other small furnaces where shallow fires are carried and where the fires can have frequent attention, The chestnut and pea sizes can, of course, be burned in heaters, but the fires must have attention several times a day, and gas explosions are apt to occur, particularly with the pea coal. This grade, and even the buckwheat size, can be successfully and very economically burned in certain furnaces of the self-feeding, or magazine type.

20. *As a general rule,* the harder varieties of anthracite, such as the "Lehigh," give better service for domestic purposes. However, the larger sizes of the more gaseous or "free burning" coals are very satisfactory for domestic use.

21. *When anthracite coals cannot be obtained,* semi-bituminous or "steam coals," or coke, may be burned in most heaters and ranges with very satisfactory results, particularly when the furnaces are given a little intelligent attention. No family need suffer if it can obtain a supply of such fuel. No fear need be entertained about the burning out of grates, particularly if the ash pits are kept clean. It is a good plan to keep a little water in ash pits, especially when coals show a tendency to clinker badly.

22. *Do not be induced to buy "fuel compounds" or "combustion accelerators"* to dissolve in water and sprinkle on the coal. These are all frauds and there is absolutely no virtue in any of them.

BURN YOUR COAL ECONOMICALLY

23. Altho every case requires individual study and some experimenting, making it impossible to lay down specific rules applicable to every condition of domestic fuel consumption, the following considerations are important:

24. *Do not operate your heater with the firing door open.* The admission of an excessive air supply is one of the principal sources of loss in the operation of a furnace, and the firing door should not be left open, or even slightly ajar, unless the fire is banked or the weather is so warm that little or no heat is required. If the fire burns up too quickly when the firing door is closed, and the "check damper" is open, the draft should be reduced by means of the "turn damper" in the smoke-pipe. Frequently the turn damper may be closed completely and the leakage past it may still be sufficient to take the gas away from the furnace with the check damper open. If gas leaks thru the upper doors of the heater when the fire is checked, the turn damper should be opened slightly, or the joint around the door plastered tight to stop the leakage (see Paragraph 16).

In the case of hot-air heaters, if the gas leaks from the furnace into the air space when the fire door is shut, and the fire is checked as above described, the heater should be repaired or replaced as soon as possible. The leakage of gas from the heater should be stopped, one way or another, as it makes an unhealthy condition in the house, and may even result in asphyxiation.

25. *Carry a deep bed of fire in the furnace.* A deep fire will further prevent loss from excessive air, particularly when egg coal is used. Keep fire bed level or slighty higher near the firing door. In mild weather a bed of ashes several inches thick may be allowed to accumulate on the grate, or the fire may be checked by throwing a shovelful of fine coal or ashes on top of it. In cold weather the ashes should be kept well shaken out from under the fire. Cold houses often result from the notion that a thin bed of fire is conducive to economy.

26. *The proper amount of coal to be fired at one time* will depend on the size of the heater and when and how it is operated. In cold weather, from 60 to 75 pounds of coal per square foot of grate area will usually be burned per day of 24 hours. If the heater is of ample capacity,

from one-half to two-thirds of the day's supply may be fired at the time the fire receives its principal attention. If the heater is of inadequate capacity, it may not be possible or advisable to fire more than one-third of the day's supply at any one time. If the heater is of the base-burning or magazine type, the above suggestions will not apply, and the manufacturer's instructions for operating should be followed.

27. *Keep the grate clear of ash and clinker,* particularly in cold weather. Remove clinkers and accumulations of slate and other non-combustible matter by passing the hook bar along the grate, thru the clinker door usually provided on furnaces for this purpose. As above stated, when the weather is mild, it is advisable to let a bed of ashes several inches thick accumulate on the grate. In shaking down the fire in mild weather, stop the shaking when the first sparks begin to fall thru. In cold weather the grate should be shaken until pieces of live coal begin to grind thru the grate. Ashes should be sprinkled with water before withdrawing from ash pit, in order to avoid dust.

28. *Save unburned coal in ashes.* With proper grates, no fuel of any consequence should be lost. If the loss is considerable, the grate shoud be changed or the ashes should be sifted. The necessity of sifting ashes should, however, be avoided by putting the grate in order.

29. *Keep gas passages in heater clean and free from soot* by cleaning once every month or six weeks.

30. *Regulate the draft carefully,* keeping the "turn damper" open only enough to maintain the necessary rate of combustion with the "check damper" closed, and to avoid the escape of gas when the check damper is open. Check the fire by means of the check damper before the house gets too warm and it becomes necessary to open windows to reduce the temperature. In windy weather the normal opening of the turn damper should be reduced to prevent the fire burning too briskly.

31. *Keep the ash pit clear of ashes,* and carry a little water in the bottom of the ash pit, if it will hold water. This will protect the grate and tend to prevent clinkering.

32. *The proper time for firing furnaces* must be determined largely by the household routine, and the duties and spare time of the person or persons who must look after the heater. In some cases it is more convenient to do the heavy chores at night, while in other cases the morning may be preferred. The capacity of the heater for the work it has to do may determine the times when the heater must receive attention. Whether the fires are coaled once, twice, or three times a day, or still more frequently, will depend on the size or coal capacity of the heater installed. In cold weather the fires may require fuel every six hours, and may need to be shaken down in the morning as well as at night, whereas, in warm weather, much less frequent attention is necessary. As a general rule, it is best to shake down the fire, coal it up heavily, and remove the ashes once a day. Where thermostat and clock control devices are installed, it is better to give the fires their principal attention late at night.

USE BITUMINOUS COAL IF NECESSARY

33. *If a hard coal supply cannot be obtained,* and it is possible to get soft coal, do not hesitate to use it. The grates of house heating furnaces may not be exactly suited for this fuel, but, by using plenty of kindling, and building the fire carefully, and shaking it cautiously afterward, very satisfactory results may be obtained.

34. *A fairly deep bed of fire,* say 8 inches to 12 inches thick, should be maintained, and the fire should be watched and the draft carefully regulated until the proper conditions of operation are determined. The fuel beds should be kept free from clinkers, but excessive shaking of grates should be avoided. The fire should be made to burn evenly over the whole grate by occasionally stirring the top of it with a poker.

35. *In firing fresh coal, the draft should be increased* and the slide in the fire door opened, to burn off the gases, after which the draft should be regulated to properly check and maintain the fire. It is not advisable to fire soft coal evenly over the whole of the grate, but to heap the coal on the front portion of the fuel bed, leaving the back of the fire thin. This method of firing will allow the gases to distil off and ignite and will prevent explosions. When the back portion of the fuel bed becomes too thin, a portion of the live coals from the front should be pushed to the back of the furnace, and fresh coal heaped in the front.

36. *In mild weather* a layer of ashes should be allowed to accumulate under the fuel bed. An ash bed will further serve to retard combustion during the night.

37. *In banking the fire for the night* a heavy bed of coal should be fired in front and the draft should be left on for ten or fifteen minutes, until the gases have become thoroly ignited. The heater can then be shut up and the draft checked the same as when burning anthracite coal.

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JOHN S. ROSSELL

REGULAR MEETING

At Drexel Institute, Monday, March 18, 1918, 8.15 P.M.

The address of the evening will be made by **Mr. John S. Rossell,** President, Security Trust and Safe Deposit Company, Wilmington, Delaware, on

"The Measure of our Sacrifice in the Present World Conflict"

Members of Affiliated Societies are cordially invited to attend.

Members of the Club and Affiliated Societies are privileged to invite ladies.

Mr. Rossell will discuss the subject from the point of view that no sacrifice is too great to make for one's country. True devotion to American ideals finds its best expression in defending and advancing those ideals. The privileges of our citizenship impose upon us the correlative obligation of rendering to the Government the fullest measure of service, whatever we may be compelled to surrender in order to make that service acceptable. In this spirit and with this purpose only can we hope to win the war. The American Engineers have shown, by their patriotic response to the Nation's call, that they are ready and willing to sacrifice all they have and all they hope for that the cause for which we give battle—the righteous cause of justice and freedom—may be triumphant thruout the world.

MEETING FOR JUNIOR MEMBERS

Tuesday, March 12, 1918, Meeting at the Engineers' Club

The following papers will be presented:

"Crucible Process of Making Steel." By A. de Macedo
"Waste Heat Boilers." By M. G. Bittel

SPECIAL MEETING

At Witherspoon Hall, Wednesday, March 27, 1918, 8.15 P.M.

The address of the evening will be made by **Mr. Howard E. Coffin,** Chairman, the Aircraft Board.

PRELIMINARY ANNOUNCEMENTS

Tuesday, April 16, 1918, 8.15 P.M., **at Witherspoon Hall, Morris Jastrow, Jr., Ph.D., LL.D.,** Librarian, University of Pennsylvania, and Professor of Semitic Languages, will present an address on **"The War and the Eastern Question."**

Tuesday, May 21, 1918, 8.15 P.M., **at the Club House.** Address to be made by retiring President, **Major John A. Vogleson.**

Tuesday, June 18, 1918, 8.15 P.M., **at the Club House.** The Junior Prize paper will be presented by the author.

SCHEDULE OF MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

MARCH, 1918

Wednesday,	**March 6, 1918**	Technology Club of Philadelphia "Steam Turbines" **H. L. Moody** (Informal dinner at 6.30 P.M., preceding the meeting)	**Engineers' Club**	8.15 P.M.
Thursday,	**March 7, 1918**	Worcester Tech Club Annual Meeting and Banquet **Dr. Ira N. Hollis**	**Engineers' Club**	6.30 P.M.
Monday,	**March 11, 1918**	American Institute of Electrical Engineers " Use of Electricity on Ships and in Shipbuilding " **H. A. Horner**	**Engineers' Club**	8.15 P.M.
Tuesday,	**March 12, 1918**	Junior Meeting " Crucible Process of Making Steel " **A. de Macedo** " Waste Heat Boilers " **M. G. Bittel**	**Engineers' Club**	8.15 P.M.
Thursday,	**March 14, 1918**	American Society of Heating and Ventilating Engineers (Second Anniversary Dinner at 6.30 P.M.) **J. A. Steinmetz**	**Engineers' Club**	8.15 P.M.
Friday,	**March 15, 1918**	Illuminating Engineering Society " The Æsthetics of Street Lighting " **S. E. Doane**	**Engineers' Club**	8.00 P.M.
Monday,	**March 18, 1918**	Regular Business Meeting Engineers' Club " The Measure of Our Sacrifice in the Present World Conflict " **John S. Rossell**	**Drexel Institute**	8.15 P.M.
Monday,	**March 25, 1918**	Philadelphia Safety Council	**Engineers' Club**	8.15 P.M.
Tuesday,	**March 26, 1918**	American Society of Mechanical Engineers " Recent Developments in Material Specifications " **Dr. S. W. Stratton**	**Engineers' Club**	8.15 P.M.
Wednesday,	**March 27, 1918**	Special Meeting Engineers' Club **Howard E. Coffin**	**Witherspoon Hall**	8.15 P.M.
Thursday,	**March 28, 1918**	Society of Automotive Engineers	**Engineers' Club**	8.15 P.M.

Monday,	**April 1, 1918**	American Society of Civil Engineers	**Engineers' Club**	8.15 P.M.
Wednesday,	**April 3, 1918**	Technology Club	**Engineers' Club**	8.15 P.M.
Thursday,	**April 4, 1918**	Worcester Tech Club	**Engineers' Club**	8.15 P.M.
Monday,	**April 8, 1918**	American Institute of Electrical Engineers	**Engineers' Club**	8.15 P.M.
Tuesday,	**April 9, 1918**	Junior Meeting	**Engineers' Club**	8.15 P.M.
Thursday,	**April 11, 1918**	American Society of Heating and Ventilating Engineers	**Engineers' Club**	8.15 P.M.

CALENDAR OF REGULAR MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

1918

DAY OF MONTH AND WEEK	NAME OF SOCIETY
First Monday	**American Society of Civil Engineers** April 1.
Second Monday	**American Institute of Electrical Engineers** March 11, April 8, May 13, June 10.
Third Monday	**Engineers' Club (March)** March 18.
Fourth Monday	**Philadelphia Safety Council** March 25, April 22, May 27, June 24.
Second Tuesday	**Engineers' Club (Junior Meeting)** March 12, April 9.
Third Tuesday	**Engineers' Club** April 16, May 21, June 18.
Fourth Tuesday	**American Society of Mechanical Engineers** March 26, April 23, May 28, June 25.
First Wednesday	**Technology Club** March 6, April 3, May 1, June 5.
First Thursday	**Worcester Tech Club** March 7, April 4, May 2, June 6.
Second Thursday	**American Society of Heating and Ventilating Engineers** March 14, April 11, May 9, June 13.
Fourth Thursday	**Society of Automotive Engineers** March 28, April 25, May 23, June 27.
Third Friday	**Illuminating Engineering Society** March 15, April 19, May 17, June 21.

Engineers' Club Meetings at Witherspoon Hall will be as follows:

Wednesday, March 27, Tuesday, April 16, **Engineers' Club** Meetings.

Members of all Affiliated Societies are invited to these meetings.

SECRETARY'S NOTICES

At the call of the President, a *Business Meeting* of the Club will be held *Monday evening, March 18, 1918,* at 8:15 o'clock, at the *Drexel Institute.*

The Committee on Nominations will present its report at this meeting.

The report of the Tellers on the vote on amendments to the By-Laws, Article I, Section 2, and Article VII, Section 2, will be announced.

H. A. Stockly, *Secretary.*

ABSTRACT OF MINUTES OF THE SPECIAL MEETING OF THE CLUB

HELD TUESDAY EVENING, JANUARY 29, 1918

The meeting was called to order, at the Club House, at 8:15 P.M., by Past President S. M. Swaab. About 250 members and guests were in attendance.

The address of the evening, "The Heavy Oil Engine," was presented by Dr. Charles E. Lucke, of Columbia University, and was discussed by Messrs. Newkirk, Boyd, Hering, Steinmetz, and Bonine.

A unanimous vote of thanks was extended to the speaker.

The meeting adjourned at 10:45 P.M.

ABSTRACT OF MINUTES OF THE SPECIAL MEETING OF THE CLUB

HELD WEDNESDAY EVENING, FEBRUARY 6, 1918

The meeting was called to order, at the Club House, at 8.15 P.M., by Mr. J. A. Steinmetz. About 200 members and guests were present.

The address of the evening, "Port and Terminal Facilities," was delivered by Dr. R. S. MacElwee, of Columbia University, and was discussed by Messrs. Webster and Ballinger.

A unanimous vote of thanks was extended to the speaker.

The meeting adjourned at 10.35 P.M.

ABSTRACT OF MINUTES OF THE BUSINESS MEETING OF THE CLUB

HELD TUESDAY EVENING, FEBRUARY 19, 1918

The meeting was called to order at the Club House at 8:15 P.M. About 200 members and guests were in attendance.

The minutes of the Business Meeting of January 16, 1918, as printed in the JOURNAL, were approved.

It was announced that the Board of Directors, at its last meeting, elected the following to membership: Active, eleven; Junior, seven.

The following motion was unanimously carried:

"That it is the sense of this meeting that the proposed amendments to Article I and Article VII of the By-Laws, as recommended by the Board of Directors, be adopted as presented."

The opinion of many present was expressed to the effect that the members would appreciate a brief statement from the Board of Directors as to the financial needs of the Club which make these amendments necessary.

The address of the evening, "Is Our Fuel Supply Nearing Exhaustion?" was presented by Dr. Robert H. Fernald, Club member and member of the U. S. Government Committee of Consulting Engineers on Coal Conservation and Publicity. The paper was discussed by Messrs. Trautwine, Nichols, Hering, Price and Maignen.

The meeting adjourned at 10:15 P.M.

SPECIAL MEETING OF THE BOARD OF DIRECTORS

FEBRUARY 5, 1918

The meeting was called to order at 7 P.M., with Vice-Presidents Yarnall and Eglin, Directors Fernald, Gant, J. C. Wagner, Kenney, Forstall, Bullens, Past Presidents Ledoux and Carter, Treasurer Stevens, and Secretary Stockly in attendance. President Vogleson, Vice-President Andrews, Directors Hayward, Henderson, Moody, R. M. Barr, and Past President Swaab were absent and excused. Directors S. T. Wagner, Ehle, and G. W. Barr were absent.

The Committee on Finance presented a report, suggesting the following amendments to the By-Laws:

Amend Article I, Section 2; by adding:

"Active Resident Members shall not exceed one thousand eight hundred in number at any time."

Amend Article VII, Section 2, by striking out "annually" and substituting "semi-annually," by adding after "April" "and October," and by striking out $15.00 after Resident Members and substituting $25.00, so that Article VII, Section 2, shall read as follows:

"The membership dues shall be payable semi-annually in advance on the first day of April and October, and shall be as follows:

Active Resident Members	$25.00
Resident Juniors	10.00
Non-resident Members (all classes)	10.00

The Board approved the proposed amendments, and ordered that they be issued to the membership in the regular way.

It was further ordered that a business meeting of the Club be called for February 19, 1918, for presentation and discussion of the amendments, and that arrangements be made for the delivery of a paper on that evening.

Mr. Stevens, as chairman of the Committee on By-Laws, was empowered to present, either thru the mail or otherwise, as he might deem advisable, the By-Laws revision, as proposed by the Board, and to explain the object of the revision at the business meeting of the Club, February 19, 1918.

The following motion, adopted at the regular meeting of the Board held September 11, 1917:

> "That the dues of any member of the Club who is in active service in the Army or Navy be automatically remitted while he is in service, during the duration of the war; and that those members in the service who have tendered their resignations, or requested remission of their dues, be notified of this action of the Board,"

upon the recommendation of the Finance Committee, was amended to read as follows:

> "The dues of any member of the Club who is in active service in the Army or Navy be remitted while he is in service, during the duration of the war, upon application to the Secretary of the Club for such remission."

This motion to apply to the next fiscal year, April 1, 1918, to March 31, 1919.

ABSTRACT OF MINUTES OF REGULAR MEETING OF THE BOARD OF DIRECTORS

HELD FEBRUARY 12, 1918

The meeting was called to order at 7 P.M., with Vice-President Yarnall, Directors Fernald, Gant, S. T. Wagner, Forstall, R. M. Barr, Douglas, Past Presidents Swaab and Carter, Treasurer Stevens, and Secretary Stockly in attendance. President Vogleson, Vice-President Andrews, Directors Henderson, J. C. Wagner, Kenney, Moody, and G. W. Barr were excused. Vice-President Eglin, Directors Hayward, Bullens, Ehle, and Past President Ledoux were absent.

The minutes of the Regular Meeting of January 8, 1918, as issued to the members of the Board, were approved. The action taken at the Special Meeting of the Board on February 5, 1918, as set forth in the minutes issued to the Board, were approved, no quorum having been present at that meeting.

REPORT OF THE PRESIDENT

A letter was read from President Vogleson, tendering his resignation as president of the Club, due to his having entered the active service of the Government, but the resignation was not accepted, as it was the expressed desire of the Board that Mr. Vogleson remain as president for the remainder of his term.

The resignation of Mr. Clayton W. Pike as chairman of the Committee on Increase of Membership was presented, owing to the fact that he has entered active Government service, and the resignation was accepted with regret, Mr. Yarnall being empowered to appoint a successor.

REPORT OF THE SECRETARY

Resignations from the following members in good standing were presented and accepted as of March 31, 1918:

C. J. Allen
H. L. Bauder
C. W. Bosler
Charles M. Clark, Jr.
Baltzar de Mare
Joseph T. Dingee
J. Arthur Hayes
Charles H. Lawall
G. Lewis Mayer
A. S. Royal
Robert T. Stetler
H. C. Toomey
W. D. Weaver

Announcement is made of the death, on September 25, 1917, of Mr. R. M. Wilson, Active Member.

The following have been transferred to the Life Membership list:

J. F. Stevens
H. P. Gant
M. A. Sherritt
Wm. H. Walters

The Philadelphia Safety Council, at its meeting on January 15, 1918, appointed the following representatives on our Board and committees:

Board of Directors, James B. Douglas.
Committee on Meetings, C. C. Black.
Committee on Public Relations, H. W. Forster.
Associate Editor on Club JOURNAL, A. C. Christie.

Mr. S. Howard Pennell, whose resignation as an Active Member in good standing was accepted at the November 13, 1917, meeting of the Board, to take effect March 31, 1918, requested reinstatement, and the request was granted.

REPORT OF THE TREASURER

The report of the Treasurer, showing unexpended balances in present fiscal appropriations, was accepted by the Board.

REPORT OF THE COMMITTEE ON HOUSE

The Committee reported that, for the month of January, the deficit in the restaurant was $87, the lowest figure since April, 1917.

It was further reported that, in order to increase the patronage, upon the completion of the new dining-room, a special platter luncheon, at fifty cents, would be served.

The report was accepted and the House Committee congratulated.

It was suggested that periodical informal luncheons be held, with a speaker on some popular subject.

REPORT OF THE COMMITTEE ON MEMBERSHIP

Upon report and recommendation of the Committee, the following were elected:

To *Active* Membership:

Victor J. Roberts
Frank C. Anderson
Edwards R. Fish
Lloyd W. Fitzgerald
Samuel Frank
Robert Lacy
Ernest C. Leete
Royal McGeorge
Chester R. Misner
John S. Rowan
Walter J. Schopp

To *Junior* Membership:

Charles S. Ballantine	D. Clark Cleaver
Stewart C. Barnett	Daniel P. Ogden
Norman C. Bye	Samuel I. Sacks
Harry R. West	

REPORTS OF SPECIAL COMMITTEES

Building Committee

The Committee reported that the work on the main dining-room, ladies' dining-room, kitchen, and new offices is progressing favorably, and it is hoped to have them completed by the end of February, provided sufficient workmen can be secured.

Committee on Conservation of Fuel

The Committee presented a report, containing a set of rules drafted by its members, regarding conservation in the use of fuel for domestic purposes, and requested the Board's approval of the rules, suggesting that they be given publicity, in the name of the Engineers' Club, in the public press and the Club JOURNAL.

The report was approved, and the function of the Committee extended to secure the publication of the rules in the public press and in any other publications it may see fit.

H. A. STOCKLY,
Secretary.

POSITIONS WANTED

Graduate of U. of P., Civil Engineering, '14, experienced in concrete construction work, railroad, and building, desires position. Apply Engineers' Club, No. 192.

Industrial engineering organization with wide acquaintance among power users, desirous to represent a reliable firm for the purpose of marketing a high-grade article or technical equipment. Apply Engineers' Club, No. 193.

Civil and constructing engineer, with 15 years' experience on heavy construction and railroad work, including masonry and concrete construction, and track laying, diamond drill work; also 4 years' experience on municipal work and all forms of road building, desires to connect himself permanently with engineering and contracting company. Apply Engineers' Club, No. 194.

POSITIONS OPEN

Wanted—Technical graduate with a mechanical turn of mind to assist in making layouts of industrial sub-stations, electrical installations for factories, and other duties, usually associated with power engineering work, for Central Station Company in Eastern Pennsylvania. Please state age, details of experience, salary expected, and references in first letter. Apply Engineers' Club, No. 187-a.

Wanted—High-grade mechanical engineers of construction experience for work on powder and explosive plants for United States Government. Please state age, nationality, experience, references, and salary desired. Apply Engineers' Club, No. 188-a.

Wanted—High-grade salesman or sales engineer to cover local field for large machine tool house. Must be of good personality and not over 40 years of age. Apply Engineers' Club, No. 189-a.

Civil engineers wanted for general survey work in housing development; including chief-of-party, instrument men, rodmen and draftsmen. Apply Engineers' Club, No. 191-a.

RESTAURANT CHANGES

At a formal dinner, held March 5th, the men's new dining-rooms were opened and turned over to the members for daily use.

In this connection the members are invited to note that a grill luncheon at 50 cents has been added to the regular service.

The ladies' dining-room is nearing completion, and notice concerning its opening and use will be made at an early date.

JUNIOR SECTION

Dr. W. M. Boehm, Chairman *Ex Officio* H. I. Goldstein, Chairman A. P. Godsho, Secretary

THE regular monthly meeting of the Junior Section was held on Tuesday evening, February 12, 1918, at the Club House, Mr. H. I. Goldstein, chairman, presiding.

The resignation of Mr. A. B. Bishop as secretary was announced, and Mr. A. P. Godsho was appointed to fill this position. Mr. M. G. Bittel was appointed chairman of the Club and Public Relations Committee, succeeding Mr. Godsho.

Mr. Zoole moved that we send a letter of thanks to Mr. Bishop in recognition of his services to the Junior Section. The resolution was adopted.

Mr. Goldstein brought up the subject of the proposed increase in dues, now under discussion among the Active Members, and expressed the opinion that the Junior dues be raised from $10 to $15 per annum and the age limit be extended from 27 years to 30 years. In this way, he contended, it would be possible to build up an active Junior Section instead of automatically making Active members who are active in name only. There was some discussion of the matter, and Mr. Goldstein decided to take the matter up with the proper authorities.

The Papers Committee announced the papers for the next meeting, March 12, 1918: "Crucible Process of Making Steel," by Mr. A. de Macedo, and "Waste Heat Boilers," by M. G. Bittel.

Mr. E. M. Bredin read his paper, "Electricity as Applied to Traction."

Mr. Bredin grouped the systems of Electric Traction now in use under four headings:

Low Tension—Direct Current.
High Tension—Direct Current.
High Tension—Alternating Current — Single Phase.
High Tension—Alternating Current — Three Phase.

Each one was briefly described and prominent examples of each were illustrated. Generation, primary and secondary transmissions, motors and control equipment were touched upon and the relative advantages of various types were compared. The conditions under which each system could be most advantageously applied were shown and examples of representative installations cited. The paper was concluded by touching upon the electrification of existing steam roads and terminals, and the possibilities of the use of high tension, single phase, alternating current in the future for electric traction work.

The lively discussion which followed showed the interest with which this paper was received.

A vote of thanks was extended to Mr. Bredin for his very interesting paper. An informal smoker followed the meeting.

Doctor Boehm calls attention to the fact that the prize of $50 in cash offered by the Club last year for the best paper presented by a Junior member has again been offered this year, but that up to the present time no papers have been submitted. Last year there were several papers presented in this competition, and this year there is no reason to expect that there will be fewer papers for the judges to choose from. However, time is getting short and a good paper takes some little time to get up. Is there any reason why the judges should not have at least twenty papers to study and compare?

In order that the work of the Junior Section, now so well begun, may not suffer during the period of inactivity this summer, and that it may start again in the fall with the minimum of friction, officers for the next year must be chosen. For this reason a committee has been appointed to look after this matter, and a report from them will be expected at the next monthly meeting. New officers will be chosen at the April meeting, April 9, 1918.

COMMITTEE ON MEMBERSHIP

D. ROBERT YARNALL, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before March 11 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

VERNON FOREST ALLEY

231 South Fortieth Street, Philadelphia, Pa.

Industrial Fuel Engineer, United Gas Improvement Company.

Proposed by J. C. Vogel and Joseph B. Seaman.

CLARENCE E. FAIRBANKS

4829 Walnut Street, Philadelphia, Pa.

Manager Electrical Department, H. W. Johns-Manville Company.

Proposed by John E. Dolbow and Issachar Murray.

MILTON W. FRANKLIN

240 West Somerset Street, Philadelphia, Pa.

Consulting Engineer, E. F. Houghton & Co.

Proposed by R. H. Horton and Lewis H. MacLaughlin.

JAMES WESLEY GALLOWAY

2nd Lieut., Co. B., 103rd Regiment Engineers, Camp Hancock, Ga.

Formerly Gas Engineer, United Gas Improvement Company.

Proposed by J. S. Bradford, Charles Elcock, and William M. White.

JAMES C. GODDARD

66 East Penn Street, Germantown, Philadelphia, Pa.

Sales Engineer, Knight & Thomas, Inc., Boston, Mass.

A. C. Roew & Son, 280 Broadway, New York City.

HAROLD S. HAYDEN

2nd Lieut., 103rd Regiment Engineers, Camp Hancock, Ga.

Assistant to Publicity Manager, Bell Telephone Company.

Proposed by J. S. Bradford, Charles Elcock, and William M. White.

LEIF E. NORBOM

237 East Johnson Street, Philadelphia, Pa.

General Manager, Delaware River Dredging Company.

Proposed by George F. Pawling and James L. Fawley.

SAMUEL HERBERT OURBACKER

West Branch Y. M. C. A., Philadelphia, Pa.

Electrical Engineer, Electric Furnace Construction Company.

Proposed by F. J. Ryan and Lewis H. Kenney.

WILLIAM J. L. ROOP

Harwood Avenue, Kirklyn, Pa.

General Superintendent, Delaware River Dredging Company.

Proposed by George F. Pawling and James L. Fawley.

HARRY J. STOCKUM

Drexel Building, Philadelphia, Pa.

Civil Engineer, Auto Appliance Company.

Proposed by J. H. Van Sciver and E. F. Cobb.

GEORGE A. WHITE

37 South Fiftieth Street, Philadelphia, Pa.

Sales Engineer, A. B. Kirschbaum Company.

Proposed by Alfred D. Morris and C. F. Bodley.

FLOYD W. WOODCOCK

107 Main Street, Salisbury, Md.

General Superintendent, Eastern Shore Gas and Electric Company.

Proposed by Charles G. Cope and James L. Fawley.

FOR ELECTION TO JUNIOR MEMBERSHIP

CHARLES UHLER BAUMAN

2nd Lieut., Co. E, 103rd Regiment Engineers, U. S. A., Camp Hancock, Augusta, Ga.

Formerly with Pennsylvania Railroad.

Proposed by J. S. Bradford, Charles Elcock, and William M. White.

L. CHEYNEY SMITH

Sunnyhill, Media, Pa.

Assistant Educational Director, Y. M. C. A., Philadelphia, Pa.

Proposed by William Easby, Jr., and W. P. Dallett.

AN ACKNOWLEDGMENT

COMPANY " B," 103D REGIMENT ENGINEERS, CAMP HANCOCK, AUGUSTA, GEORGIA.

January 20, 1918.

Engineers' Club of Philadelphia.

GENTLEMEN:

We, the undersigned members of Company " B," 103d Engineers, beg to express our appreciation of the generosity of the members of the Engineers' Club of Philadelphia in sending the splendid Christmas gifts to this command.

The packages were distributed at New Year's and cemented once more the bonds of friendship between our mother organization and the boys in the field.

Please accept our best wishes for the continued prosperity of the Club and of the individual members.

(Signed)—

Arthur J. Hafer
Sergt. J. S. Kelly, Jr.
Sergt. Wm. H. Pahl
A. L. Hisler, Jr.
Sergt. W. W. Hartman
Wm. R. Turner
W. I. Jones
F. J. Lundy
L. G. Anderson
Alfred M. Campbell
W. McClintock
Joseph H. Kelley
William B. Tower
Harold M. Jordan
Jarrett G. Harvey
Kenner A. Harvey
S. W. Rinehart
Geo. J. Enggasser
George Yerkes
Harry Byers
A. L. Simons
Corp. B. F. Spylın
Corp. A. W. Farley
Ralph O. Strassner
Sgt. B. Kohler
E. G. Coolbaugh
Harry A. Jeffcott, Jr.
Leo J. Curly
John F. Hartman
Corp. D. W. Bartholomew
Corp. R. C. Gregg
Don Harpham
Fred J. Street
Sgt. H. B. Marsh
Corp. F. F. Roy Worley
Saddler M. E. Templeton
Robert E. Hoeflich
Corp. G. D. Hoppes
Wm. G. Daymon
C. Walter Dunlap
Joseph Myers
William E. Allen
Chas. P. Penningler
C. L. Keagle
W. F. Finley
Paul Thompson
Porter Thompson
J. L. McGrane
L. I. Zellner

F. C. B. Anderson
F. J. Vaules
J. S. McAfee
Henry E. Bonnin
John B. May
G. B. Plunkett
F. L. Hoffa
A. F. Steininger
Budd Owen
Frank J. Woods.
Jack D. Moses
Charles E. Mullen
Alfred C. Cryer
W. J. Harvey
Francis J. Buckley
Bernard Burke
Patrick Quinn
William Powell
Sergt. H. W. Hoele
George Thomson
Robert C. Greer, Jr.
F. Kendall Brown, Jr.
W. A. Dehlschlager
Arthur Warner
Edward C. Worley
J. H. Bean
Albert Gemel
Lt. Edw. N. Butler
Lt. Charles Elcock
Lt. H. T. Hayden
Lt. J. W. Galloway
Lt. W. M. White
J. S. Bradford, captain
Sgt. John P. Easby
1st Sgt. Paul F. Quinlan, Jr.
Sergt. G. Lauber
Sergt. 1st class Samuel L. Leithiser
Corp. Ralph C. Celig
Corp. Claude M. Metetska
Sergt. James D. Butler
Sgt. W. S. Jopson
Franklin J. Graham
William B. Taylor
Herbert W. Coy
Eber W. Light
Fred R. Fox
William Lawrence
Corp. Jack P. Greene

C. O. Pahl
R. J. Stanford
Charles J. Fitzgerald
Leslie Henderson
Edw. S. Apgar
Corp. Roy Saunders
Henry F. Bamberger
Arthur G. Frees
Ralph K. Briner
Sergt. Walter H. Young
Private L. R. Price
John A. Keenan
William Kay Rhodes
Harold Forrest Hamill
James B. Duffy
Kenneth G. Stin
William G. McCausland
Ernest Boucher
Charles J. Corcoran
James J. Norton
James H. Nickel
John T. Andrews
John Neuman
D. Tullis
Sgt. F. M. Harder
Roy Sparling
Albert Herman
James J. Bradley
Joseph R. Ely
Charles J. McDangree
A. H. Smith, Jr.
John J. Callahan
Meredith M. Titus
William M. Longenberger
Nicolai Aachmann Hansen
Wilford E. Register
Harry G. Stahl
Sergt. A. K. Ruby
Arthur B. Wanner
Charles F. Veith
Albert E. Simpson
Sergt. Wm. H. Hall
Cook C. H. Reed
J. Ward
A. Sparling
Cook H. Burns
Corp. E. H. Haux
E. W. Jones
A. C. Young

H. A. Kiesel
Harry B. Kappauf
Paul J. Quimby
William A. Zirkman
Sergt. William G. Chaney
Edward Shenton
Godfrey R. Thorn
Ira C. Scull
John A. Flanagan
Sergt. L. M. Kline
Earl Troutman
Harry Linsky
John E. Cloud
George W. Robinson
Harry J. McAvoy
Chas. Kemmerly
O. W. Keichner
Thos. Hagarty
Peter K. Meshong
Corporal D. N. Sharpe
Corporal S. W. Thorpe
Serg't Gerril H. Baigh
Robert A. McClure
James C. Brawley, Jr.
George W. Powell, Jr.
Simon Morris
Leo T. Garrity
R. Menaugh
E. A. Clarke
Corporal Stephen
G. L. MacGarrigle
W. J. Tate
F. A. Adair
J. H. Paul
Wm. M. Merz
J. R. Steininger
Frank R. Clough
Marion M. Crewe
George A. Pukv
Le Roy Coleman
F. Ruff
Corp. S. J. Reynolds
C. J. Frederick
Oscar Williams
Alexander Boyd
Fighting Al. Pyatt
Corporal C. C. Bream
Robert Donaldsen
John F. Schneider

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, Chairman

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF FEBRUARY 20, 1918

NAME	RANK	CORPS	LOCATION
Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, H. Butler	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, France
Allen, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Anders, D. W.	Captain	Company D, 502nd Engineers	Overseas Service
Andrews, J. H. M.	Major	Ordnance R. C.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
Asplundth, E. T.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Atterbury, W. W.	Brigadier-General	Director-General of Railways	France
Barker, E. W., Jr.		Truck 4-304 Ammunition Train	Camp Meade, Admiral, Md.
Bassett, P. H., Jr.		Officers' Training School	Camp Meade, Md.
Bear, H. K.	Private	Gas Defense Service	Washington, D. C.
Bell, Frank F.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
Betus, A. J.		111th Infantry	Camp Hancock, Augusta, Ga.
Biester, W. H., Jr.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Bishop, A. B.		Radio School	Little Silver, N. J.
Booz, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	France
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. F.	1st Lieutenant	U. S. Naval Reserve Senior Engineer Officer	U. S. S. "Jupiter"
Boyd, G.	1st Sergeant	Overseas Repair Section No. 1	Gas Defense Service, Medical Corps
Bradford, J. S.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Bradt, Morris	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Bransome, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
Bream, C. C.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Breen, J. W.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, France
Brewer, P. C., Jr.	2nd Lieutenant	307th Engineers	Camp Gordon, Atlanta, Ga.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Broadhead, Alex.		19th Reserve Engineers	American Expeditionary Forces, France
Broderick, D. F.	Major	Ordnance Officers' Reserve Corps	Rock Island Arsenal, Rockland, Ill.
Brown, J. A.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier-General W. W. Atterbury
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, France
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. F.	Lieutenant	462nd Co. (Motorcycles), E. M. S. S.	Fort Myer, Va.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.		Carriage Division, F. A. Section	Washington, D. C.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Chance, T. M.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Childs, H. P.		7th Infantry	
Colgan, R. J.	Captain	11th Regiment Engineers	Care of Adjutant-Gen'l, Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	Camp Hancock, Augusta, Ga.
Crowther, E. C.	Corporal	Jefferson Hospital Unit	
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Cutler, James B.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Derby, C. F.	Captain	Ordnance Officers' Reserve Corps	Camp Lee, Petersburg, Va.
Dill, C. M.		Company K, 319th Infantry	Camp Lee, Petersburg, Va.
Donnelly, J. B.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Doyle, T. H.	2nd Lieutenant	Quartermaster Officers' Reserve	Camp Meade, Md.
Dunlap, V. R.	Lieutenant (Jr.)	Ass't Civil Engineer, U. S. N.	Pensacola, Fla.
Dunn, M. L.	Ensign	U. S. S. Connecticut	Care Postmaster, N. Y.
Dyson, C. W.	Rear Admiral	Bureau of Steam Engineering, U. S. N.	Washington, D. C.
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.

Elcock, Chas.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Farr, Roy S.	2nd Lieutenant	301st Engineers' Train	Camp Devens, Ayer, Mass.
Faust, W. D.		103rd Engineers	Camp Hancock, Augusta, Ga.
Fenton, Powell		Aviation Corps	France
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	Overseas Service
Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	American Expeditionary Forces, France
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	Laurel, Md.
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	Washington, D. C.
Gauthier, Jordan	2nd Lieutenant	56th Engineers	Washington, D. C.
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, France
Getz, Ralph F.		19th Reserve Engineers	American Expeditionary Forces, France
Gilbert, W. T.		21st Railway Engineers	France
Gillan, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Gilpin, F. H.	Inspector of Ordnance	Research Laboratory, Picatinny Arsenal	Dover, N. J.
Gracey, A. L.	Private	Ordnance Officers' Reserve	Watervliet Arsenal
Gravell, W. H.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, France
Gribbel, W. G.	Captain	30th Engineers	Overseas Service
Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C.
Grossman, P. R.	Private	447th Depot Detachment Engineers	Camp Devens, Ayer, Mass.
Gwilliam, Mark R. M.	1st Lieutenant	21st U. S. Infantry	San Diego, California
Hall, W. A.	Lieutenant	Naval Coast Defense	Overseas Service
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	105th Engineers	Camp Sevier, Greenville, S. C.
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hathaway, H. K.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
Heger, J.	Lieutenant	Engineers' Depot	Washington, D. C.
Henry, J. C.		Headquarters Dep't 19th Reserve Engineers	American Expeditionary Forces, France
Hetherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Infantry	Charlotte, Ga.
Hollenback, E. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.	1st Lieutenant	Dental Corps, 28th Division	Camp Hancock, Augusta, Ga.
Houwen, W. P.	C. Ma. A.	United States Navy Air Station	Cape May, N. J.
Hulme, Norman	1st Lieutenant	458th Truck Co.	Fort Myer, Va.
Hyland, G. N.	Cadet	U. S. A. Flying School	Park Field, Memphis, Tenn.
Jones, Jonathan	Captain	23rd Regiment Engineers	Camp Meade, Md.
Kennedy, J. H.		Aviation Section, Signal Corps	American Expeditionary Forces, France
Kern, F. X.	Lieutenant	23rd Regiment Engineers	Camp Meade, Md.
Kneass, E.	Ensign	U. S. Naval Academy	Annapolis, Md.
Knight, C. C., Jr.	Lieutenant	81st Division, Field Artillery	Camp Jackson, S. C.
Koelle, W. F. B.	Sergeant	Signal Corps	Washington, D. C.
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	American Expeditionary Forces, France
Lawrence, G. E.	Lieutenant J. G.	Naval Coast Defense	Overseas Service
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Levin, J.		2nd Officers' Training Camp	Fortress Monroe, Va.
Lynch, N. L.		Engineer Officers' Reserve Corps	Washington Barracks, Washington, D. C.
MacGarrigle, G. L.	Private	Company "B," 103rd Engineers	Camp Hancock, Augusta, Ga.
Magee, J. W.	2nd Lieutenant	504th Engineers' Corps	Washington Barracks, D. C.
Mallon, G. J.	Lieutenant (Jr.)	U. S. Naval Reserve Force	U. S. S. "Mt. Vernon," care of Postmaster, N. Y.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Mardaga, L.	Ensign	U. S. Naval Reserve Force	Asst. Naval Inspector of Ordnance, Alloy Steel Forging Plant, Carnegie, Pa.
Martin, T. S., 3rd	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Mayburry, W. G., Jr.	Lieutenant	334th Field Artillery, National Army	Camp Pike, Ark.
McCausland, J. R.	Master Engineer	446th Engineers, Depot Detachment	Camp Devens, Ayer, Mass.
McClintock, J. L.		U. S. Navy Radio Service	Parkway Bldg. *pro tem.*
McCord, J. B.	Lieutenant-Colonel	Ordnance N. A.	War Department, Washington, D. C.
McCormick, J. C.	1st Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, France
McCoy, J. F.	Cadet	Aviation Section, Signal Corps	Park Field, Memphis, Tenn.
McGarrigle, J. J.		2nd Officers' Training Camp	Fortress Monroe, Va
McMillan, H. L.	Major	303rd Engineers	Camp Dix, Wrightstown, N. J.
Millar, E. A., Jr.	1st Lieutenant	Ordnance Officers' Reserve	Camp Hancock, Augusta, Ga.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Moon, T. E.	Corporal	119th Ordnance Depot Co.	Camp Hancock, Augusta, Ga.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Myers, W. C.	Captain	Ordnance Officers' Reserve	Washington, D. C.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	Captain	312 Machine Gun Battalion	Camp Meade, Admiral, Md.

Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixon-Miller, M.	Captain	Company "B," 501st Engineers	Camp Merritt, N. J.
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
Oakes, J. C.	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Orr, M. W.		First Battery, Officers' Training School	Camp Meade, Md.
Otwell, Curtis W.	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Perry, Edward		Quartermaster Officers' Reserve	Camp Lee, Petersburg, Va.
Peterman, J. M.	Private		Camp Meade, Admiral, Md.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Prichett, F. B.		103rd Trench Mortar Battery	Camp Hancock, Augusta, Ga.
Prince, H. W.		Squadron 80	Camp Eimerman, Fort Worth, Texas
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	79th Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	19th Reserve Engineers	American Expeditionary Forces, France
Reed, Thomas	Captain	Ordnance Officers' Reserve Corps	Office of Inspector of Ordnance, U. S. A., Plainfield, N. J.
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Reninger, H. A.	Major & Adjutant, A.G. Dept.	53rd Depot Brigade	Camp Hancock, Augusta, Ga.
Ridge, R. S.	Sergeant	23rd Engineers	Camp Meade, Admiral, Md.
Ridgway, J. J.	1st Lieutenant	Co. F, 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.		Electrical Research Dept., Aviation Section, Signal Corps	Mineola, L. I.
Roop, J. C.	Captain	17th Engineers	France
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	Washington, D. C.
Schmidt, A. H.		Company "C," 315th Infantry	Camp Meade, Admiral, Md.
Schoch, J. B.	Lieutenant	109th U. S. Infantry	Camp Hancock, Augusta, Ga.
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defence Service, Med. Dept., U. S. A.	Washington, D. C.
Sheahan, J. C.	2nd Lieutenant	Co. 11, Section B, Bldg. 6	Camp Jos. E. Johnston, Jacksonville, Fla.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Smith, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	Overseas Service
Spillan, J. J. D.	Sergeant	Hq. 53, Brig. F. A.	Camp Hancock, Augusta, Ga.
St. John Everett,	1st Lieutenant	Coast Artillery Reserve Corps	Fort duPont, Delaware
Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	1st Lieutenant	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
Thacher, C. H.	2nd Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
Thomas, R. S.	Lieutenant Colonel	312th Engineers	Camp Pike, Little Rock, Ark.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Corporal	Co. "B," 103rd Engineers	Camp Hancock, Augusta, Ga.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Maine"
Uhler, W. D.	Major	Quartermaster Corps, N. A.	Aberdeen, Md.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal
Vaughan, D. L.	1st Lieutenant	Officers' Reserve Corps	Camp Joseph E. Johnston, Jacksonville, Fla.
Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Coast Artillery	Fort Greble, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces via New York
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	Engineer Officers' Reserve Corps	France
Wentz, E. M.	Asst. Paymaster	Receiving Ship	Brooklyn Navy Yard
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	Camp Hancock, Augusta, Ga.
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	C. A. C. School D	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Alex. Remaunt Depot, Macon Ga.
Zeckwer, J. A.	Ensign	U. S. Naval Reserve Force	Boarding Officer, Port of Philadelphia
Zinn, George A.	Colonel	District Engineers' Office, Custom House	Portland, Oregon

TECHNOLOGY CLUB OF PHILADELPHIA

H. A. Terrell, President. N. A. White, Secretary, Wenonah, N. J.

MARCH MEETING

THE next meeting of the Technology Club will be held on Wednesday evening, March 6, 1918. Mr. H. L. Moody, '07, of the Westinghouse Company, will speak on "Steam Turbines." There will be the usual informal dinner at 6:30 P.M. and meeting at 8:15 P.M.

FEBRUARY MEETINGS

A special meeting was held at the Drexel Institute on the evening of February 12 to meet Prof. C. Frank Allen, 1872, of the Civil Engineering Department of Technology. Professor Allen was returning from a trip among the various alumni clubs, having visited the Technology Clubs of Schenectady, Syracuse, Detroit, Chicago, Minneapolis, St. Louis, Kansas City, Akron, Cleveland, Indianapolis, Urbana, Cincinnati, Pittsburgh, and Washington. Professor Allen's accounts of the various activities of the new Institute at Cambridge and the news items which he brought from the various alumni centres were most interesting. The major part of Professor Allen's talk was, of course, devoted to the war activities at the Institute and the work of the alumni in connection with the war, but the many intimate stories of the present student life and reminiscences of the older professors at the Institute were much appreciated. The thanks of the Club are due our fellow alumnus "Allen, class of seventy-two," and to Doctor Godfrey and Professor Ryder for their hospitality at Drexel Institute.

The regular February meeting was held at the Engineers' Club on Wednesday, February 6. Mr. W. R. D. Hall, secretary of the Publicity Bureau of the Philadelphia Chamber of Commerce, spoke on the "Engineering of Civic Efficiency." The purpose and functions of a Chamber of Commerce were described and its activities considered in relation to "Engineering."

Mr. Hall described the work of a Chamber of Commerce in providing means for discussion of community affairs and in crystallizing public opinion. The Philadelphia Chamber of Commerce was described as being a typical example. It is divided into the following Bureaus with paid secretaries: Charities, Conventions and Exhibitions, Foreign Trade, Industrial, Transportation, Membership and Publicity. In addition, there are Committees on Agriculture, Banking and Currency, Insurance, Law, Legislation, Entertainment, Finance, Harbor and Navigation, Municipal Affairs, Postal Affairs, Public Utilities, Trade Expansion, War Shipping, and an Executive Committee. The membership of the Chamber of Commerce is further divided into groups according to professions and trades, with chairmen for each group, the chairmen being members of a Council, which is an advisory body to the Board of Directors.

For the year 1918 the Philadelphia Chamber of Commerce has planned active constructive work in connection with:

1. Plans for a Greater Philadelphia, including parts of Delaware and Bucks counties.
2. Plans for arbitration of commercial disputes.
3. Improvements in street-cleaning methods in Philadelphia.
4. Revision and readjustment of tax assessments and tax rates.
5. Organization of "retail groups."

The above are normal activities of the Chamber of Commerce, but during the present year various war committees are at work, the most active at present being the War Shipping Committee, and the members are unselfishly devoting their time to Government affair.

WORCESTER TECH CLUB

George A. Denny, Chairman   **Robert M. Barr**, Secretary, Land Title Building

THE regular monthly meeting of the Worcester Tech Club was held at the Engineers' Club, February 7, 1918, and included the usual dinner and a short business meeting, following which the paper of the evening, "Compression Rheostats," was read by Mr. A. H. Allen, manager of the Triumph Electric Company, of Philadelphia. A general discussion of this type of rheostat followed the presentation of the paper.

A number of prospective new members were present from the Aviation Section of the U. S. Navy.

The annual meeting and banquet will be held March 7 next, when Dr. Ira N. Hollis, president of the Institute, will be the guest of the evening. Owing to war conditions, the dinner this year will be informal in character.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS ∴ PHILADELPHIA SECTION

Lewis F. Moody, Chairman.   **John P. Mudd**, Secretary, Midvale Steel Company, Nicetown, Pa.

FEBRUARY MEETING.

CARL BARTH, well-known engineer and efficiency expert in machine-shop methods, gave a paper, which was a mathematical analysis of the present income tax. It is expected that this paper will be published in the JOURNAL and also the *Journal of The American Society of Mechanical Engineers.*

MARCH MEETING.

This meeting will be held on the 26th of the month, and the subject will be "Recent Developments in Material Specifications," by Dr. S. W. Stratton, Director of the United States Bureau of Standards.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

EASTERN PENNSYLVANIA CHAPTER

George W. Barr, President   **George Boon**, Secretary

THE next meeting of the Eastern Chapter of the A. S. H. V. E. will be held Thursday evening, March 14, 1918.

This being our second anniversary, the meeting will be preceded by an informal dinner at 6:30 P.M., to be held at the Engineers' Club.

The Meetings Committee has announced as the speaker of the evening, Mr. Joseph A. Steinmetz, president of the Aero Club of Pennsylvania. Mr. Steinmetz has not decided on his subject at this time, but those members who have had the pleasure of hearing him before well know that he has the good fortune of always being able to give interesting talks.

The election of officers and a Board of Governors for the ensuing year will also be held.

Our meeting of Thursday evening, February 14, was very well attended. Mr. C. V. Haynes, the speaker, presented a continuation of his paper of December 13, 1917.

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-4 APRIL, 1918 NO. 161

PORTS AND TERMINAL FACILITIES*

BY R. S. MACELWEE

THE port problem is a railway problem even more than a ship operating problem. It should be one of the three links of transportation—railway, port, ship—but the railway end of the trilogy is the one which has been most neglected and the one which has broken down under the strain of the war demands on transportation.

The problem is a serious one. If there be no quick dispatch of railway cars at the marine terminals the inland transportation system of the country will be paralyzed and we will have no coal nor many other things. We are sore pressed for ships, but if, because of the inefficiency of the ports and the railways at the ports here and in France, we turn the ships around only fast enough to allow a round trip every twelve weeks instead of every six weeks, the result is the same as if the Germans had torpedoed half of the existing meagre tonnage. On the other hand, if we are able to coördinate and operate the terminal ports here and in France so as to turn the ships around quickly and make the round trip in six weeks instead of twelve, we have doubled the efficiency of our present merchant shipping without having built another ship. The port problem is as important a war measure as the ship problem.

Also, after the war, struggle for the markets of the world will be fierce. Any "*frais paracites,*" any practical expense at the terminals, will act as an increased cost of production of American goods. Transportation is just as much a cost of production as raw materials or labor. If we are to hold and enlarge the markets for American goods, which will mean smoking chimneys and full dinner pails for American workers, we must scale down the unnecessary costs. Low wage costs do not mean low wages. Low wage costs per unit of product mean increase in the productivity of labor. Investments in terminal facilities do not mean higher costs per ton of traffic.

The port is one point where the unnecessary costs of production of American goods can be scaled down. Just as in the design of an aviation motor or of an aeroplane, the way to make the machine light is to reduce the weight a little here and a little there. There is no short cut. One little saving added to another little saving will in the end make a large difference in the weight of the motor and also in the cost of putting American products on the markets of the world. This is our only hope to meet the competition of many lands which in the past have been at this sort of thing more intensely than we. In particular, so far as inland water transportation and port development are concerned must we turn to the illustrious enemy. The great French engineering paper, *Le Genie Civil,* has been preaching this point constantly during the past two or three years. *Le Genie Civil* takes the stand that it is a peculiar kind of patriot who thinks it is unpatriotic to learn all that can be learned from the enemy. Such a patriot should be watched.

The port and terminal problem is one for both engineers *and* economists. There has been no real coöperation between the two sciences in the past. There has been a tendency to build wonderful piers as engineering structures which do not link up with the rest of the system, and there has been port planning which would not stand up because of the engineering deficiencies. The day and age has arrived when there must be a new profession of engineer-economist to solve involved transportation problems, just as the patent attorney must be a lawyer and an engineer. The building of efficient ports will require the best engineering talent in the land. Americans can build, judging from the achievements on the Great Lakes, where bulk cargo loading transport and unloading have far surpassed any like achievement abroad. Our American engineers are more than equal to the task if given conditions which are right. The failure of our American ports in this crisis is not due to the engineers. The forces at fault are far less conspicuous and far more elusive than the failure of American ports at the present time is due to the peculiar conditions of American railway history—in particular, the competition of rival lines at the terminals. A new era in American railroading is dawning, and it is for this new era that we must plan. Planning and execution will require engineering-economists.

At the very beginning of the problem we must note what may be called the reservoir principle. The system of transportation from an American factory to a foreign consumer is composed of many movements, each distinct, each part of the whole. Transportation over rails, carts, piers, ships, etc., involves a series of distinct movements, each complete in itself. These separate movements cannot be entirely synchronized. The result is that one movement does not keep pace with the other. Where the joint occurs there is either lost motion or congestion. It is like the internal-combustion engine which develops power every fourth count or every second time the fly-wheel turns over. That is why there is a fly-wheel: to take up the power when it occurs and carry it over the dead centers. In a transportation system there is the same sort of intermittent motion along the route. With the exception of belt and bucket conveyors and pipe lines, there is no continuous movement. Continuous movement is the ideal to which freight handling aspires. Therefore fly-wheels or reservoirs must be devised at the terminals of each intermittent movement to take up the load and hold it until such time as it may be carried farther. The fewer the number of cylinders the larger the fly-wheel. The greater the irregularity of ships, freight trains, or canal barges entering a port, the more provision must be made for carrying the load over the dead centers. For instance, the ore and coal stock piles at the steel works on the Great Lakes must carry over a five months' dead center of frozen navigation, while our cities cannot exist five days without coal.

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* Presented before the Engineers' Club, February 6, 1918.

The two great reservoirs are the *warehouse* and the *transit shed*. As subdivisions of these two units there are many minor points where reservoirs are necessary, such as the point of deposit of freight transferred from the hold of the ship to the wharf. Freight must not " hang " for lack of place to set it down. There are also points of deposit for loading carts or freight cars or barges or lighters.

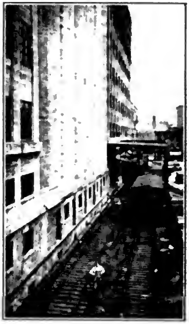
There is no blanket expedient; no panacea; no cure-all. Each point must be discovered in the particular system, and each case solved on its own demerits.

The railroad problem is too complex and at present in such a state of flux that it is beyond the scope of this paper to enter into the discussion. There are certain fundamental principles which must be stated, however, before it is possible to go on with the consideration of a few details.

With equal facilities for handling and equal port charges, the port with the widest choice of transportation facilities to the interior will be the greatest port. These facilities include the waterways. The largest ports of Europe are the ports at the mouths of great navigable water systems: Rotterdam on the outlet of the Rhine and Meuse systems; Hamburg on the Elbe-Oder system. Antwerp is the port for the Scheldt and Belgian-French canal and waterway systems. Inland water navigation is important to the port. Nevertheless, even in the case of the highly developed German waterways two-thirds of all the tonnage travels by rail. The ports mentioned are great because there is a large *choice of connections* with the interior. It is not waterways *vs.* railways, but waterways *and* railways which make the port attractive to shipping. Many connecting lines act as the increase in the number of cylinders which makes a motor run smoothly.

If the port with the best prospects is the port with the most connections by rail and water with the interior, it follows that there must be *equal, universal,* and *free* movement between any pier and any railroad line. To this must be added universal connection with any warehouse.

A port must be a unit in respect to all its terminal facilities. Altho far from being an ideal port, New York has grown beyond all other ports because of this universality of railroad connection. The complete harmony between every ship and every rail line is accomplished by so-called "free lighterage." Even at a high cost the advantages of the coördination have been so great that the expense of lighterage and the freight rate differentials have been offset by better service and the port has prospered. Other ports of the North Atlantic have been railroad terminals in the narrow sense of terminals for one railroad. The railroad has considered that the pier and then the ship berthing at the pier is a part of the private system of the railroad company. There have been no terminal charges against the freight in this case, and the ships are given free wharfage at a railroad pier. Free wharfage does not begin to offset the fact that the ship line has access only to the narrow hinterland served by one railroad system.


DETROIT MILL, SHOWING RAILROAD SIDING IN CONNECTION WITH WATERSIDE DELIVERY. BOTH SORTS OF TRANSPORTATION ARE NECESSARY

The principle that a port must be one zone with equal charges to any part of it has been upheld by the Interstate Commerce Commission. It has been argued against the separation of terminal charges from the line haul that European hotels may charge guests for candles and soap, but this is not the American plan. The comparison limps. We have yet to find a first-class American hotel which includes the wine bill in the room rent. With terminals operated as a unit there must be a separation of charges. *There must be physical connection between every pier and every railway and every warehouse at a uniform charge.*

How is complete flexibility between piers and railway accomplished? The belt railway is the solution. There are two kinds of belt lines: the outer belt line, which connects the railroads before they enter the port area, and the inner belt line, which connects the piers with each other, with the outer belt lines and with the main lines. It has been contended in hearings and in the press that New York does not need a harbor belt line, because the waters in the harbor serve better than any belt line could do. Universality is accomplished by the lighterage system, and this has helped to make New York great. Now is it peculiar to the port of New York that the harbor has water in it? There is not quite as much water at New Orleans, Montreal, Hamburg, Manchester, and elsewhere, but San Francisco has even more water than New York. Yet these ports have belt lines. We Puritanical Americans are inclined to look at everything from the moral standpoint: that it is either all good or all bad, either black or white. There are no shades in between. There may or may not be gradations between good and bad in morality, but in port development there are all sorts of things which taken together make a good port. No one thing will do it.

The function of the harbor belt railway is to enable carload freight to come directly to the pier-shed without rehandling. As will be discussed later, this does not mean that lighters are to be abolished. On the contrary, harbor lighters, both large and small, are a most neglected asset. The economic waste to be eliminated is opening a car and transferring its contents to a lighter to be towed to a ship when the car should be switched to the pier-shed over a belt line, to be unloaded into the pier-shed to await the arrival of the ship. Note that it is never considered for a moment to load a ship directly from the cars. There are exceptions in the case of large and heavy pieces which should be brought alongside on gondola or flat cars. However, this is a small proportion of all the miscellaneous cargo of all the ships. A recent high port authority and also a metropolitan daily with an editorial writer of renown on these subjects have argued continually that ships cannot be loaded from railway cars directly, therefore why have a belt line at all? No one intends to load from car to ship as a regular routine. Rehandling is the expensive part of freight movement. Towing lighters and switching cars are small items of the total. For instance, in handling carload freight in New York the switching costs in New Jersey are ten cents a ton, out of a total of $1.25 a ton for delivering the carload to New York. This is for a twenty-ton load average, or $25 the car. This figure is only payroll expense and includes nothing for the investment. The belt line eliminates several of these expensive handlings of carload freight.

IN-STREAM UNLOADING FROM STEAMER TO BARGE FOR THE INTERIOR WATERWAYS BY MEANS OF PNEUMATIC ELEVATORS

The best American example of a belt line is at Montreal. Here the car is switched from any rail line to any pier at a flat rate of $5 the car. For the year 1916, out of total receipts of $375,000 there was a profit of $100,000 from the belt line service. The belt line does a local drayage service for all private warehouse and industrial plants located on spur tracks of the belt line at a flat rate of $2.50 the car.

Also at New Orleans the belt line has been a success.

At San Francisco the same institution has shown the same success. For some time there was a link missing in the belt, and it cost about $12 a car to car-float around the missing link. This service was done by a railroad company, which collected accordingly. The incident brings out another axiom: *"A belt line, to be a success and give universal coördination between every pier or warehouse and every railway, must be entirely under one management and perform the switching service anywhere at one flat rate to all."*

At Hamburg the harbor railway has a total length of tracks of 185 miles. For less than carloads, minimum 5 metric tons, the belt line charges are about ten cents per 100 pounds. For carload it is 1½ cents, and, to discourage the use of wharf sheds as far as possible, the charge is only three mills per 100 pounds when the transfer is direct from ship to car and the cars are moved at once.

Before mentioning various successful port institutions at home and abroad, we may reiterate that port planning involves the establishment of two main reservoirs, the pier-shed and the warehouse, with a completely flexible universal connection between them and all vehicles by land and water. Keep constantly in mind *flexibility of physical connection and reservoirs,* to be sure we are talking about the same thing. We may define a port as harbor *plus* terminal facilities.

A railway and ship-line map of the world will show the obvious fact that the centers of densest railway nets are connected by the most ship lines. Western Europe and Eastern United States are the first great nets connected by the North Atlantic " Ferry." The third greatest railway net is the La Plate district of South America. A large bundle of shipping lines connect it with the other two. Ports widely separated compete with one another for the commerce of the hinterland. There is usually a more or less clearly defined economic drainage basin which discharges thru a given port. Rotterdam has the Rhine Valley, Hamburg the Elbe-Oder, Antwerp all of Belgium and Northern France. Antwerp economically could not possibly be a German port. New York competes with New Orleans and with Montreal. A glance at a map showing the movement of wheat from the

"Head of the Lakes" will show that New York, Philadelphia, and Baltimore compete successfully with Montreal, in spite of the excellent management and equipment of that port. *The reservoir factor of Buffalo,* with its eighteen or more great elevators, takes up the sudden thrust of the harvest during open navigation on the Lakes and gives out the grain again in an even flow during the time that Montreal is frozen shut. The port with the best facilities and the cheapest movement combined will extend its hinterland. The greatest known efficiency in bulk cargo handling is on the Great Lakes. Ore and grain come down and coal goes up. The Lakes likewise offer a two-way haul and no empties.

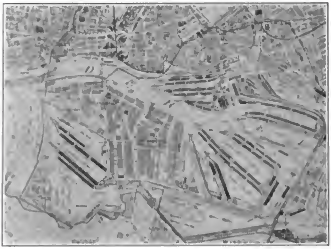
The efficiency of the Lakes is due to complete harmony between boat, pier, and railroad car. The Lake boat is all hatches. I counted thirty-eight hatches on one boat last summer. These hatches are twelve feet between centers. The ore pier has a row of pockets or bins, each twelve feet wide, which are filled by twenty-four-foot cars from the mines. Boat, bins, and cars all register. The bins hold 350 tons. When a boat comes alongside with all its hatches open, a chute from each bin is lowered into each hatch and the sluices open. The record for loading 10,000 tons of ore is twenty-four minutes. The great Hewlette "Grasshopper" unloaders with fifteen-ton grab buckets will unload such a boat in less than three hours. In thirty years the unloading costs have been reduced from fifty-six cents to four cents per ton. The per ton mile cost of transportation is one-half of one mill.

The efficiency of a port is not its size. A map illustrating the "Biggest-in-the-World" idea in the case of New York shows a map of New York occupying one-half of the page. Drawn to the same scale, the ports of Hamburg, Rotterdam, Liverpool, London, Amsterdam, Bremen, and Antwerp all together occupy the other half. This is a very poor commentary on the efficiency of New York. It does indicate the size of the problems confronting our greatest gateway, but when each of the other little dug-out-of-the-mud ports, without breaking down, have handled almost as much commerce as all of New York, then there must be something wrong on this side with New York. Several European ports, notably Marseilles, yearly average over 500 tons of cargo transferred over every linear foot of equipped quay, as against 150 tons at New York.

For the sake of knowing what we are talking about, attention must be called to the use of the word *dock*. There are no docks at Hamburg, but open tidal basins. At Bremen, Antwerp, and London there are docks.

The docks of London were dug out of the river banks. Owing to the tide variation of about twenty feet the water in the basins was shut off from the river to maintain a constant level. A dock is a basin locked off by water-gates from the changes of tide or water level of the river or harbor. The expression "to dock a ship" has been corrupted to mean berthing a ship anywhere, and, finally, to mean the structure to which the ship is berthed. Thus a perfectly good pier, wharf, or quay is incorrectly called a dock. This leads to endless confusion, just as it does to use the word *gun* when one does not mean artillery at all, but a rifle.

Antwerp, before the war, had planned one of the greatest digging efforts, but the port of Antwerp suffers from the conflicting municipal and state authorities. The plan was afterward abandoned. The idea was to dig a canal, called the Grand Coupure, across the bend in the Scheldt and then construct a lock canal several miles long, with nine basins, 2500 to 3500 feet long and 300 to 400 feet wide. These basins were to be added as the demands of commerce required, and were to be fully equipped with cranes, sheds, spur tracks, and upland for classification yards, warehouses, and industrial development. The old basins, some dating from Napoleon Bonaparte, are small affairs in comparison.


HAMBURG

Bordeaux also intended to build a dock harbor on the locked canal and side-arm-basin principle. This has been commenced. The structures, which look like piers, are not piers in the American sense, but tongues of land several thousand feet long, faced with masonry quay walls. Pile structures are not practical in such large units.

Manchester, the inland town which became a port, has docks and quays. The longest docks are 2700 feet by 300 feet. It seems that in Europe whenever a harbor is dug out of the ground the quay system and not the pier system prevails. Most of these harbors are dug out of low-lying marsh land, and the spoil of the dredges is used to fill the land to a sufficient height for building construction.

Tilbury docks, London, are an excellent example of the dock harbor and the artificial basin. There is a tidal antechamber or waiting basin and locks thru which a ship passes into the constant level water of the dock. The dock consists of a turning basin and three slip basins of 300 feet width between two filled piers 1600 feet long. These piers carry spur tracks at each edge and down the

QUAY EQUIPMENT, BONAPARTE BASIN, ANTWERP

center, and four transit sheds on each quay. Back of the piers are the railway classification yards.

The reason of the narrow pier is historical. The city or state had title to land under water at the extension of the streets, and the pier was therefore no wider than the streets of which it was an extension. The piers were large enough for the ships at the time they were built. This is no reason for retaining the narrow pier system for large modern ships.

The vexing question of the width of piers includes the factors of tracks, of cranes or other transfer machinery, and the question of the amount of cargo which the pier will be required to hold.

In the first place, the pier-shed, *unencumbered with teams, railway tracks, or other obstructions,* must be large enough to hold without crowding the entire cargo of the largest ship using the berth. An analysis of the most successful ports shows that at least ten square feet per measurement ton of cargo has been the practice. The floor space is what counts, as there is great loss of effort in tiering more than shoulder high in a transit shed where the freight remains only a few days. We must keep clearly in our minds that the pier-shed is a reservoir to collect and hold the cargo for a ship until the ship is loaded, or to receive the cargo of the ship as fast as the ship can be unloaded and hold it until the goods can be taken away to the warehouse or other destination. Cargo must be assembled before a ship arrives at its berth in order to have it classified as to port of destination and for proper stowing.

Also, cargo must be gotten out of the ship as rapidly as possible in order that the ship may load and leave again. All this requires much handling. This handling requires elbow room. Ten square feet per ton of cargo of the largest ship is the minimum space to allow. This would mean a shed 1000 by 150 feet for 15,000 cargo tons. It has been found that a better dimension is 750 by 200 feet. This seems a very wide shed to most of us, but this is the dimension of the most recent layouts abroad, at ports which have found the other sizes inadequate.

For short distances not over 200 feet there is no substitution for the hand truck as to flexibility. It is quicker to run across the pier from the hatch than along the pier.

Above everything, freight must not be allowed to "hang" in the ship slings while unloading. It *must* be gotten away as fast as it comes out. To prevent "hanging," stevedores are kept waiting. This is a loss.

There has been much talk about eliminating the hand truck. The hand truck cannot be eliminated. There may be devised many helps and aids for the longer haul. The hand truck becomes uneconomical above a certain distance of 150 to 200 feet. It is then worth while to pick up the load by mechanical means for a longer haul. There is the electric truck for this purpose.

The electric truck requires skilled attention and smooth pier deck.

The telfer requires a heavy superstructure and skilled operation. The possibilities of both electric and telfer are great.

Particularly promising is the removable body in connection with the telfer and the system of store-door delivery. This system uses the hand truck or lurry for short movements to within reach of the telfer. The loaded lurries are picked up bodily and carried to the waiting motor truck chassis, which are built to carry two each. The inauguration of store-door delivery by zones with pooled terminal facilities should make the telfer and the removable body practical. Also, the dray would be banned from the pier-shed, where it is such a nuisance.

THE ANCIENT SYSTEM OF WATER-SIDE DELIVERY AS PERFECTED IN THE MODERN FREE PORT WAREHOUSE DISTRICT. LIGHTERS DO THE WORK ELSEWHERE DONE BY DRAYS, CARTS AND TRUCKS

The narrow covered pier accommodating only one ship and not over 1000 feet in length is not so inefficient when it serves only as a transfer bridge. This is its function at New York. As there is no belt line connection by rail at New York, and as this service is done by the lighter, the berth opposite the discharging ship is left free for lighters. The freight is trucked across the pier from the ship's sling to the lighter.

Some efforts have been made to make the cross-pier movement by mechanical means. This effective system is satisfactory so long as the deck of the pier, the floor of the pier-shed, is kept free from obstructions, such as drays and railroad tracks. There is no place for railroad tracks on the usual narrow pier. It is too small as it is.

So long as the pier serves as transfer bridge from ship to lighter there is really no need of rail connection.

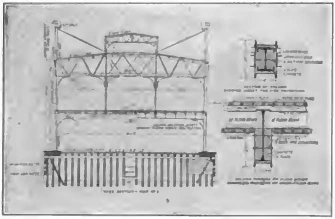
With the introduction of the belt line connection from transit shed to railway system the question arises where to put the tracks on the pier. At one of the Bush piers the tracks are simply laid down the middle of the pier flush with the pier deck.

Cars are not only difficult to load from the track level, but the pier deck is now cut in two. When the deck is divided by tracks it becomes necessary to have each half large enough to hold the entire cargo of a ship. The result is two transit sheds separated by the railroad track.

This has been done in the new Philadelphia piers. They are 300 feet wide and carry what amounts to two sheds separated by two railroad tracks down the middle. Goods when unloaded and classified are trucked across the deck of the pier, not to waiting lighters, but to waiting freight cars.

What has become of the lighters? They are too valuable a piece of harbor equipment to fall by the wayside. The lighters, as at Hamburg, London, and elsewhere, have much to do. They handle less than carload freight to ships in stream, goods from local warehouses and manufacturers on the water front. Also, freight in less than fifty-ton lots to river barges.

The lighters must now lie on the water side of the ship and receive freight directly from the ship overside. Also, they may come alongside the pier after the ship has gone. Here the crane is a great advantage over the cargo mast or ship's tackle, and an explanation why it is so universally used at the best European ports, in particular at those ports where there is much lighter and barge traffic.



A NEW YORK PIER WITH CARGO MASTS

As soon as the lighters come into the pier slip as part of the day's work it becomes necessary to make the pier slip wider. Otherwise there will be no room for ships and lighters. The kind of congestion which ensues is seen at some of the old pier slips, only 125 feet wide. Lighters often become wedged in and miss the boat. Philadelphia is allowing 300 feet as the latest slip width.

A new pier at Cleveland, Ohio, shows a successful effort to connect the steamer with the railroad. The pier is 700 feet long by 300 feet wide. On either side, set back from the water's edge, are the pier-sheds, and in the center of the pier, back of each shed, is a pair of railroad tracks. In the center of the pier is a wagon road. However, with the width of the pier there could be added several times the length. A single narrow pier cannot be much over 1000 feet in length without loss of efficiency and congestion. However, when the wide double pier is once started, with adequate rail and teaming roads in the center and with the freight movement crossing the shed to the tracks or teams in the rear instead of down the pier to the bulkhead, then there is no reason why the pier should not be extended to 3000 or 4000 feet. A pier of this type is nothing but the European quay system. A narrow pier cannot have tracks, trucks, or length. A wide pier can have all of these.

HAMBURG—A LOAD OF HARVESTING MACHINERY BEING LIGHTERED FROM SHIP TO WAREHOUSE INSTEAD OF DRAYED; CHARGES 30C. PER 100 LBS.

Commonwealth Pier, Boston, failed for lack of universal connections by rail. However, the middle should have been left for cars and teams and not covered for warehousing.

The question of *car tracks on the water side of the pier is completely involved in the question of freight-handling machinery.* The movement from ship to car and from car to ship is not frequent, and only in the case of certain heavy articles which require particular machinery. As the usual gantry crane in vogue is of three tons capacity, and seldom over five tons, it is usually necessary, even in the best equipped ports, to have a floating derrick come alongside and negotiate heavy loading.

In European ports packages of three tons are loaded directly from flat or gondola cars to ship just as at New York from cars to lighter.

The most recent works at Bremen show a wide pier-shed set well back from the water's edge, with floor level with freight car floors and served by great semi-portal gantry cranes of imposing dimensions.

At Hamburg the cranes are set every 100 feet along the quay wall. The railroad tracks at the ship's side are only for emergency. They are therefore set flush with the pavement in order to allow easy trucking across them.

When the freight comes out faster than it can be taken away by the stevedores it is never allowed to "hang," but it is set down at the most convenient vacant space. A ship tackle or cargo mast has a deposit area of eight to ten feet square; a crane, twenty to forty feet.

Four to six of these cranes work a ship, sometimes eight. Two can usually work at each hatch. The usual rate of discharge at Hamburg is 250 tons of general cargo per hour. The record of the *Saxonia* at Boston a few years ago was 190 tons an hour. The Liverpool Handbook cites the case of *The Lake Champlaney*, which discharged 12,000 tons of measurement cargo in forty-eight hours, which is an average of 250 tons an hour. The record at New Orleans for side port delivery is 130 tons an hour, but it cost seventy-five cents a ton. With cranes working for a record, they should do 500 to 800 tons per hour. The charge for the use of the public cranes at Hamburg is three cents a ton.

A similar layout, only smaller, may be noted at the municipal port of Stettin, on the Baltic.

Along the basins at Antwerp there is full crane equipment, but the sheds have been set well back, without any elevated platform for loading into railway cars. Some of the sheds have rail connection at the rear and some have not. There is plenty of room to maneuver, but the feeling of security from pilfering is not great. Some of the basins are lined with cranes, but have no sheds at all.

At Stavanger, in Norway, there are neither quays nor sheds, but there are tracks to allow the goods to be brought alongside the ship within reach of the ship's tackle and thus reduce handling and hand trucking to a minimum.

At Valparaiso, Chile, there is found the European quay and crane system of layout. The ports of South America represented improvements of one billion francs for the ten years before the great war.

It is often stated axiomatically that the pier-shed should be as close to the edge of the pier as possible. We have just seen that well-organized ports set the sheds back thirty to thirty-five feet from the quay wall. Again, both systems are right, depending on circumstances. Cranes have a longer reach, and there is also more room inland in the quay system. In the case of the pier there is so little room for deck space that the entire surface must be utilized.

A recent wharf at Jacksonville has gone ever further from the water's edge than necessary. A semi-portal instead of a locomotive crane and the shed nearer the water's edge would have been better. However, when a smaller port does as well as this it should be congratulated and not scolded.

The new Galveston cotton warehouse wharf embodies much of the most approved and modern practice. The wharf apron carries two car tracks spanned by two semi-portal gantry cranes. Across the wharf are the freight car tracks. The shed is two stories of concrete, and both floors are served by cranes and freight cars. Locomotive cranes, as at Jacksonville, will occupy much more room than the semi-portal crane.

The cargo mast is a fortunate compromise. It is often argued that the reason the European ports use cranes is because the freight cars are open, and the Americans do not use cranes because of the prevalence of the box car with us. This is like saying that it is warm in summer because there is no snow. The fact that the cranes are used extensively is the reason for the prevalence of the open freight car. The use of the crane is to be found due to the fact that water transportation by barges makes unloading machinery on shore necessary. Also, a potent reason is the fact that the equipment is supplied by municipal authorities not looking to a large return on the money. Still another reason is the fact that more cargo passes over a municipal public quay per linear foot, and therefore the burden of the additional cost of the quay equipment is more diluted per ton lifted. A final reason is that the quay system has more room back from the water's edge.

The American machineless unloading may be defective, but there is no room on a narrow pier for cranes. The cargo mast is a successful compromise. On the pier edge masts carrying a girder at a height of seventy-five to eighty feet above low-water deck extend along the water's edge. A block and tackle with a line from a drum hoist on the pier to the hook is berthed to this girder. A ship's boom and hoist also operates another line to the same hook. There are three movements. Where the load in the hold is attached to the hook, (1) the ship's winch raises the load; (2) the pier winch then starts to pull and the ship's hoist lets go; (3) the pier hoist then lowers the load. The movement is without lost motion and by the shortest possible route. The cost of installation is low, the saving is great. The cost of operating two hoists and two operators instead of one is greater than with the crane. For the sea ship the system is splendid, but useless for barges. Both the crane and the cargo mast operate at about forty cycles an hour.

AT STAVANGER, NORWAY, THE QUAY HAS NO MECHANICAL EQUIPMENT, BUT IT HAS RAILROAD CONNECTION, AN INDISPENSABLE ELEMENT OF THE PORT

It has been mentioned that at many ports where the connection with the interior by water has been well developed, cargo ships (bulkers) discharge overside in stream while moored to pile clusters or Duc D'Alves. For this no wharfage is charged at Hamburg. The expensive wharves charge fees on their general cargo which the low-grade bulk cargo will not bear. A ship carrying the major part of the cargo in bulk and a small part of it high-grade package freight will do better to stay at the mooring posts and have the freight lightered to her.

Rotterdam planned the port to accommodate water connection with the Rhine. Each new basin to be dug out of the land has been wider and with more rows of mooring posts. The first group of basins, in the town, built about 1600, were small. There were ten of them. The next four were built about 1879 and were much larger. The Maas Haven, opened in 1905, covers 150 acres and has three rows of mooring posts. A town was torn down to make room for it. The last great basin, the Waal Haven, not yet completed, will cover 700 acres with many rows of dolphins.

The system of overside discharge in stream has developed a particular type of cargo boat. The importance of the Rhine navigation may be gathered from the fact that in 1913 there was a Rhine fleet of 4400 boats with a cargo capacity of 2,326,000 metric tons, and that 16,300,000 tons going down and 19,000,000 tons going up the Rhine crossed the frontier in 1913. The total Rhine navigation was 76,000,000 tons. Barges as large as 3500 tons leave Rotterdam. This shows what can be done with the Barge Canal and the Mississippi River.

At Hamburg only about half of the entire tonnage movement is negotiated in stream. The basins are, therefore, not entirely for mooring-post berths. A single row of posts to accommodate two rows of ships is sufficient. There are ten miles of such mooring posts. One of the most modern basins shows steamers loading and unloading at both quays, with lighters and barges alongside, and also two rows of cargo boats in stream discharging into lighters and barges. There is a heavy duty floating derrick alongside one ship and the pneumatic grain elevators alongside another.

Pneumatic elevators discharge grain overside into barges. Several elevators will work at one ship. The rate of discharge from ship to barge per elevator is seven to eight hundred tons per nine-hour day. Four machines will therefore transfer 3000 tons, or 112,000 bushels per working day.

The harbors of the Atlantic seaboard at the present time are full of ships anchored and taking freight, in particular explosives, overside from lighters. In-stream loading is necessary in this case because of the nature of the cargo, as well as because of congestion at the pier. However, without protection and from choppy warehouses, the steamer swinging about at her moorings with every change of wind and tide, the work is dangerous, and the amount of harbor area required per ship is great. With the opening of the barge canal in-stream loading at dolphins should become a necessity.

The Warehouse.—The pier-shed is the reservoir to hold a shipload for one sailing. That is why we call it a *transit* shed. The warehouse system is the reservoir for the entire port for months and seasons. The present collapse at the ports is due not only to the fact that the transit sheds do not hold a full cargo, but to insufficient warehouse space to hold any overload of traffic. Mr. Geddes, a famous English expert in port and freight handling matters, said to me that the Antwerp authorities figured on a warehouse capacity of one and one-half times the cargo capacity of the port.

ROTTERDAM

The Rotterdam warehouses are located near the water front. They are built in the place of a pier-shed a short distance back from the water's edge, within reach of long-arm jib cranes. Some are connected by a bridge spanning the marginal sheet.

In Brooklyn they use a telfer to establish physical connection between the transit shed and the warehouse across a marginal driveway and railway. Direct connection is an absolute essential. The warehouse must be completely connected with the water front and with the railway service.

One handsome set of London warehouses has only dray connection with the other means of transportation. Many of the Liverpool warehouses must cart every pound of freight to and from their doors. This is a fearful economic waste. But at Liverpool, as at New York, these conditions have been a bad heritage from prerailroad times. On the other hand, the goods house of the London, Tilbury, and South End Railway is an example of the best intensive development of the modern railroad freight terminal in direct connection with the Tilbury docks, linking ships, transit shed, and railway net.

The Calvin Tomkins plan for the West Side of New York went a step further and applied the principles of intensive freight-house development to the marine terminal warehouse. The result is a freight warehouse with direct rail connection, in the lower levels, with the transit shed of the steamship pier by means of a short spur track, and with the truck railroads by belt line loading facilities for local cartage are ample. A similar plan of many-storied warehouse over the freight yard is nearing completion in Chicago for the Pennsylvania Railroad. The structure is not only modern in equipment and of enormous dimensions, but architecturally a marvellous edifice. The day of the open freight yard and the isolated warehouse is past. Urban freight terminal yards now occupy only warehouse basements. Cuppers' Terminals at St. Louis are a notable example. At the Bush Terminals the rail, pier, and dray coördination is accomplished.

A warehouse should be built with only eight or nine feet between floors. With low tiering not much waste headroom is required, but as many floors as are desirable are possible. Also, it is found to be more economical to hoist the cargo to the warehouse floor, not by elevators, but from the outside by means of long-arm cranes or "whip hoists."

The matter of warehouse location with respect to the wharf is important.

At Bremen, Stettin, and elsewhere the warehouse has been located directly back of the transit sheds and across a marginal driveway.

THE ANCIENT SYSTEM OF WATER-SIDE DELIVERY TO WAREHOUSES BUILT ON CANALS AS DEVELOPED IN HAMBURG

Goods intended for the warehouse are trucked across the shed deck to the rear, where the crane picks them up and sets them into the floor of the warehouse where they are to go.

This seems very good in theory, but let us look at the situation more closely. Suppose a merchant keeps his stock all together in a warehouse, and a ship with a consignment for him docks at a wharf a mile down the quay. It will be necessary to cart the consignment a mile along the water front. The warehouse might as well be a mile inland. The carting is the very thing it was sought to avoid by locating the warehouses directly behind the transit shed.

Warehouses and Water-side Delivery.—The warehouse system which affords the greatest flexibility is *the warehouse group with water-side delivery* by lighter. At New York and elsewhere the lighter has grown to be of 600 tons capacity, and its service is to continue the journey of a train load of freight which has reached the end of its track. There is, however, a small, fast lighter which is not designed to supplant the railroad car, but to eliminate as far as possible the dray or truck traffic with the warehouse.

Goods brought alongside the warehouse in "lighter drays" are hoisted directly into the warehouse by electrically operated fall ropes.

This lighterage trucking system at Hamburg was an historical heritage. The "new warehouse town," opened in 1888, was built with access to the warehouse by means of a lighter canal. On the land side the warehouses face a street for drays and spur tracks as any other warehouse.

This system, which is developed at Rotterdam and at Hamburg, is an evolution, not an invention. Hamburg was a free and independent city-state from 1292 until 1871. Since then its extensive residuary state rights, of which the Free Port is one, make it an *imperium in imperio*. For this reason the port of Hamburg has been worked out and also paid for by the Hamburgers and by no one else. However, the English influence has been so strong that Napoleon called Hamburg "Cette sale ville anglaise."

When the town was founded, in 1811, in the marshes of the lower Elbe delta, as in the case of Venice, for safety, it became a city of canals. Along these canals the Hanseatic merchants built their warehouses, with the front or office part toward the street and the warehouse overhanging a canal in the rear called "a fleet." The ships anchored in the Elbe.

An old map of 1796 shows a row or two of mooring posts and a log breakwater. Connection between ship and warehouse was by lighters, which are poled or "staked." Lighters are still handled that way in London. The modern method is to tow them with oil-burning motor tugs operated by one man.

The first breakdown to this system came with the advent of the steam railroad. As early as 1835 the English engineer, Charles Vignoles, planned harbor improvements for Hamburg with rail connection from the quays and from the warehouses. It was considered an economic waste in 1835 to dray carload freight from warehouses to railway yards.

The first modern quay was opened 1866. The first municipal warehouse in the harbor fitted with rails and cranes was built in 1872. It was expected that seagoing ships would berth alongside the quay and discharge directly into the floors of the warehouse. This was soon found to be impractical, as, with few exceptions, all cargo must be spread out on a roomy shed floor, to be assorted according to marks. As ships increased rapidly in size the chances of discharging directly from ship to warehouse decreased.

With the incorporation of the state of Hamburg into the German Customs Union and the creation of a Free Port Zone of "customs outland" the entire warehouse system in the town became obsolete. The creation of the free zone of about 1200 acres outside the customs barrier made free zone warehouses necessary. Accordingly 16,000 people were moved from an island near the heart of the business district, but within the Free Port, the buildings razed, and here a warehouse city was erected. The important part of it was that in order to retain the ancient system of lighter movement between warehouse and ship a lighter canal was cut thru the center of the area.

The " lighter dray " gives complete flexibility from any pier-shed in any far-off basin or from a ship in stream to any one of the group of warehouses near the city. Draying, except for local consumption, has been almost eliminated. The lightermen perform the draying service at competitive rates in the neighborhood of two and one-half cents per 100 pounds. Lighters carry 40 to 100 tons.

The study of the peculiarities of a port's freight movement is essential. At the Bush Terminals the movement of freight is analyzed as this:

30 per cent. is destined for the warehouse (by means of elevated truck, mule " lurry ").

25 per cent. carload railroad freight (usually car floated).

25 per cent. less than carload railroad freight (usually lightered or car floated).

20 per cent. dray for local delivery.

At Hamburg the half of the freight which does not go overside in stream for barge transportation on the interior waterways, but over the quays, has the following distributions:

18 per cent. by rail (carload and less than carload).

20 per cent. dray to local consignee (or less than carload to railroad).

45 per cent. by lighter to warehouses or to river express barges.

17 per cent. goes into barges over the quay after the ship has left or over the water side of the ship at the quay.

It must be plain that the belt line does not eliminate the lighter. The belt line simply takes care of freight moving to and from the interior by rail. Even in railroad New York this is only half of the movement of the great Bush Terminal.

Within the free zone and likewise in the town are to be seen canal systems which are not of the usual harbor character. These are industrial sections with water-side delivery. Mr. Lindley, an English engineer, built one section by the cut-and-fill system of swamp-land reclamation. A private warehouse in Hamburg which has no canal side delivery is considered very inferior and commands only about one-half the usual rent. In hunting for a warehouse for elevator construction service station at Hamburg I found this generally to be the case.

Water-side Delivery for Industries.—The advantages of receiving coal by barge or lighter, not to mention other materials, are convenience and a large saving in expense. There is great economic advantage of locating large industrial plants, in particular heavy industries, where both water and rail connection are possible. The French have recently awakened to the advantage which such location has given the Germans in the past. *Le Genie Civil,* in 1917, devoted several articles to the subject. Granted water transportation cheaper than by rail, the principle underlying the water-side location is that the low-grade raw materials are less able to carry the freight charges, and that the volume is greater than the finished product which can bear the charges.

At Frankfort-sur-Main the commercial port is completely equipped. The industrial terrain is located upland and has only land vehicles to serve it.

A FLOUR MILL AT DETROIT, SHOWING THE ADVANTAGE OF WATERSIDE DELIVERY

In the case of Neuss, that progressive municipality built the river port purely as an industrial harbor. Among other industries, the town succeeded in getting the International Harvester Corporation to locate on twenty-five acres. Municipal salesmanship is a fine art. Such a side-arm-canal port costs so much to build that if the price asked be based on a calculation of the cost of construction divided by the length of water front and then the cost per unit of water front found by dividing by the depth of the plot, the proportion of cost per square foot of factory land would be prohibitive. No business could stand it. However, the rivalry of some forty river port towns along the Rhine is so great that the municipality pays the excess cost of the harbor and knows that the growth of the industry, with its increased earning power under conditions of complete traffic coördination, will more than offset the cost thru the increased tax returns, increased population, and general civic prosperity.

The water front of a rail-bound Mississippi River town shows a sad contrast. Times are changing, however. The port of Duisberg is a coal center. In 1913 the movement of the port was 25,000,000 tons, mostly coal. It is equipped with sixty coal car tippers. Some of the basins are a mile long.

Not only the river port, but also the sea port, if the nature of the ground is such, can lay out an industrial harbor with side-arm canals to enable lighterage to supersede draying for many kinds of freight. Bremen has done this. The Vacuum Oil Company is one concern located in this industrial harbor.

The great problem in building the water connection is to diffuse the high costs of the harbor works over sufficient upland. This is a machine technical problem which will give our best engineers much opportunity to show their ingenuity. How can the benefits of water-front properties be extended as far as possible inland? is the question. Major Fordyce has utilized a chain-drive overhead trolley or telfer to connect cotton warehouses with the wharf. This has been a cheap and effective expedient at both Texas City and Mobile. The problem of moving general cargo is more difficult. There surely are some queer packages to be moved in general cargo.

At Detroit a certain flour mill has seen the advantages of complete water and rail connection. The wheat and other grain comes by boat in bulk from the Northwest and is loaded directly into a concrete elevator at the water's edge. Just back of the elevator and connected with it is a mill. At one side of the mill are spur tracks for the rail service. Given universal rail service by means of a belt line, and the coördination of transportation facilities is complete. Economic waste is reduced to a minimum.

The opportunity of side-arm canals and water-side delivery by lighter is offered whenever low marshy ground is reclaimed for industrial uses. It is about as easy to dredge the canals and use the spoil as fill as not to do so. A municipal port authority trust is the most satisfactory organization for land reclaiming and industrial and commercial port development. The scattered efforts of individuals cannot accomplish this. This was proven at Rotterdam, at Cuxhaven, and elsewhere in the '70's. An industrial part can be developed only when the area and the number of tenants are large. Newark Bay or Jamaica Bay is such an opportunity. The bay is far larger than the entire harbor of Hamburg. The development is by nature doomed to lighterage connection with the great cargo ships at the port of New York. Therefore, why not provide for lighterage streets, alternating with the dray and railroad streets? This will give the most economical connection.

The one great point to leave with you is that a port is not only a harbor, but includes terminal facilities. Terminal facilities include piers, warehouses, belt railways, lighters, and industrial as well as commercial harbors. The truly coördinated port is one where every part is connected with every other part; every pier with every trunk line; every warehouse with every pier; every trunk line with every ship in stream and with every industrial plant in the port area. This is what is meant by universal flexible coördination at ports with terminal facilities.

DISCUSSION BY MR. GEORGE S. WEBSTER,

Director of Department of
Wharves, Docks and Ferries,
Philadelphia.

We are all indebted to Doctor MacElwee for his splendid talk showing what has been accomplished in the principal ports of the world. It is especially gratifying to hear what he told regarding the importance of economy in operation. We, as engineers, feel that we can build piers substantially, and we recognize that there must be economy in their operation if we are to compete with other ports.

The policy of the city of Philadelphia, as many of you know, is gradually to acquire the property along the river front, so that there may be had here a municipally controlled and operated port, similar to New Orleans and San Francisco. With that object in view, a comprehensive plan has been worked out and designs made for pier construction in the southern part of the city. The piers as planned are of ample width to accommodate the business that we believe will come to them, and particularly to facilitate the delivery of goods by trucks, for there must be delivery of goods to all piers from nearby points of production. We find that those who handle trucks in the city of Philadelphia have very much less objection to going farther to a wide pier where there is no congestion or delay than to a smaller pier that is the center of congestion, where they may wait for several hours, or even an entire day, to unload their cargoes.

There are superior advantages in Philadelphia—advantages which meet the various specifications laid down by Doctor MacElwee as the requirements of a perfect harbor. We have the advantage of a public belt-line railroad along the river front, and, while the present belt line, it must be admitted, has not accomplished all that it was hoped it would, nevertheless it is a railroad chartered, planned, and operated in the public interest, and is capable of being improved, so that it can be a real public belt line, fulfilling all the purposes for which it was designed. You will remember when the city secured an agreement with the railroad companies in the South Philadelphia project it was distinctly set forth that the tracks should be laid around the southern section of the city and be constructed as a joint railroad and as a gateway for any railroads that might in the future desire to enter the city. With this as a beginning, we have the first essential to a port, getting cargoes directly to the water front cheaply, over sidings leading to the piers, and public piers are all connected with a belt line, so that every railroad entering this city may have the freest opportunity without any restriction, without preference, without any advantage over another, to enter upon these piers and discharge its cargoes.

We have extending along the river a splendid commercial avenue which will be developed from League Island to north of Tacony—a distance of probably twenty-one miles. This avenue will be made of sufficient width, the lower section being 250 feet wide—[West Street, New York, is 200 feet wide]—to accommodate trucks and teams and give opportunity for manufacturers to haul directly to the river front; and this is no small matter, for Philadelphia and the area around it is a great manufacturing center.

There is in Philadelphia about one-fiftieth of the population of the United States, but we produce about one-twentieth of the manufactured products; and then in the

(Continued on Page 208)

IS OUR FUEL SUPPLY NEARING EXHAUSTION?*

By **R. H. FERNALD**, Member

THE VITAL IMPORTANCE OF FUEL

"FOOD will win the war; don't waste it." This effective slogan has convinced us of the very essential part which conservation and proper distribution of food are to play in the ultimate winning of the war. Few of us, however, appreciate how vitally essential, if not paramount, is fuel in the great world struggle. Our slogan might well be: "Fuel and food will win the war; don't waste them."

Some months ago the Honorable Franklin K. Lane, Secretary of the Interior, was reported as saying: "Not only food, but fuel is a vital need of this country and of our Allies—coal to run the ships and railroads, to feed the iron furnaces, and furnish steam for all the manufacturing plants, coal in greater quantities than have ever been mined in the United States or in any part of the world; and this is being met in truly American fashion by the operators and owners of the mines and by the diggers of the coal."

As pointed out by Van Hise† in 1910: "Coal is by far the most important of all the mineral products. Next to coal in importance is iron. These two are of much greater consequence than all of the other mineral products put together. The existence of extensive coal and iron fields has profoundly influenced modern civilization. The greatest commercial nations are Germany, England, and America, and each has extensive coal and iron deposits. Little Belgium, because of its important coal and iron deposits, is a hive of industry, occupying a position as a manufacturing nation far beyond what one would expect from its limited area and population."

The supreme industrial value of coal and iron deposits clearly substantiates the claim that France needs not only Alsace-Lorraine, but also a very small strip of land (about three hundred square miles) close to Saarlouis, Germany, as shown by a glance at the maps in the *Philadelphia Public Ledger*, December 2, 1917, for here lie some of the finest coal deposits of the continent of Europe.

That fuel is the backbone of the present titanic struggle for world supremacy was completely driven home by the recent collapse in Italy. "For the want of coal her industries stopped; for the want of shells her guns were spiked; for the want of guns her army was powerless; for the want of an army her country was conquered by the Hun—and all for the want of some tons of coal."

THE WORLD'S COAL SUPPLY

If it be true that the domination of the world will rest with those nations that own or control the two most important natural resources—coal and iron—a somewhat startling sidelight is thrown on our possible relation to the great problems of the present century by Campbell's‡ figures on the coal reserves of the world.

Coal Reserves of the World

	Short tons
Americas	5,627,823,500,000
Asia	1,410,487,600,000
Europe	864,412,600,000
Oceania	187,842,900,000
Africa	63,755,900,000
	8,154,322,500,000

The portion falling to the United States alone is 4,205,154,000,000 tons, or over half of all the coal in the world.

The coal reserves by countries are as follows:

	Short tons
United States, including Alaska	4,231,352,000,000
Canada	1,360,535,000,000
China	1,097,436,000,000
Germany	466,665,000,000
Great Britain and Ireland	208,922,000,000
Siberia	191,667,000,000
Australia	182,510,000,000
India	87,083,000,000
Russia in Europe	66,255,000,000
Union of South Africa	61,949,000,000
Austria	59,387,000,000
Columbia	29,762,000,000
Indo-China	22,048,000,000
France	19,382,000,000
Other countries	69,369,500,000
	8,154,322,500,000

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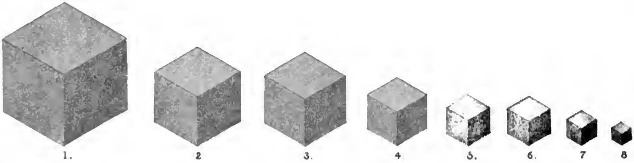
* Read at Special Meeting, Engineers' Club, February 19, 1918.

† "The Conservation of Natural Resources in the United States," Charles R. Van Hise.

‡ United States Geological Survey Professional Paper 100-A, by M. R. Campbell.

COAL RESERVES OF THE WORLD BY COUNTRIES.
(SHORT TONS.)



1	UNITED STATES	4,231,352,000,000
2	CANADA	1,360,535,000,000.
3	CHINA	1,097,436,000,000
4	GERMANY	466,665,000,000
5	GREAT BRITAIN	208,922,000,000
6	SIBERIA	191,667,000,000
7	RUSSIA	66,255,000,000.
8	FRANCE	19,382,000,000.

AMOUNT OF COAL AVAILABLE IN THE UNITED STATES

Of the tremendous stores of coal in the United States a considerable portion lies below a practical mining depth. Altho in some instances in European countries coal has been mined at a depth of 6000 feet, it is hardly probable that for many years commercial conditions in this country will warrant the removal of coal at a greater depth than 3000 feet below the surface. Fortunately nearly nine-tenths of the total estimated original coal reserves, or about 3,550,000,000,000 tons, lie at a depth not exceeding this 3000-foot limit.

Altho we are becoming accustomed to talking in billions, it is hardly possible to grasp the meaning of thirty-five hundred and fifty billion tons of coal. Perhaps some conception of this amount may be had from the statement that if all the unmined coal within 3000 feet of the surface could be placed in one great cubical pile as solid as it now lies in the ground the pile would be eight miles long, eight miles wide, and eight miles high, *i.e.*, the length, the breadth, and the height of this great cube would be equal to the distance from City Hall to Hunting Park.

Living in Pennsylvania we are inclined to think that the greatest coal deposits of the country are in the East and largely in Pennsylvania. An examination of the government reports on the subjects reveals the fact that the two greatest continuous coal areas lie in Montana, Wyoming, and the Dakotas, and represent nearly three and one-half times the total coal reserves of the entire Appalachian region. A serious situation confronts us, however, when we realize that our really high-grade coals—the semi-bituminous and anthracite of the eastern provinces—amount to less than one-seventh (or about 15 per cent.) of the available coal reserves of the country.

Approximately an additional 15 per cent. may be classed as coal of medium grade, but the bulk of our coal—70 per cent. of the entire supply—consists of low-grade bituminous coals and lignites.

It is perhaps well to correct a rather general impression that anthracite is the highest grade fuel. As a matter of fact, our semi-bituminous coals rank first, as shown by the following table of comparative heating values per pound of combustible material:

	B. t. u. per lb. (ash free)
Semi-bituminous	15,420
Anthracite and semi-anthracite	14,660
Bituminous	13,970
Sub-bituminous and lignite	8,560

The exhaustion of these semi-bituminous coals would be a far greater calamity than the exhaustion of the anthracite supply, as they are much better adapted for general commercial purposes and are more efficient than anthracite, the latter being used but little outside of the domestic field.

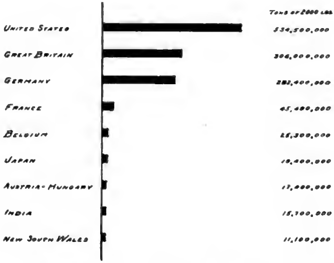
WORLD'S PRODUCTION OF COAL

Naturally figures on the production of coal in Europe are not available for the past two or three years, but the relative production of coal by the different countries of the world in normal times is shown by the following figures for 1912:

World's Production of Coal in 1912

Countries	Short tons
United States	534,500,000
Great Britain	306,000,000
Germany	282,400,000
France	45,400,000
Belgium	25,300,000
Japan (1911)	19,400,000
Austria-Hungary	17,400,000
India	15,700,000
New South Wales	11,100,000

World's Production of Coal in 1912

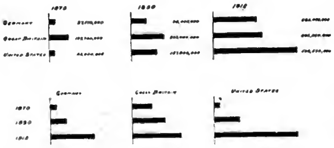


Of the world's production for the year 1912, 1,364,000,000 tons (82 per cent.) were produced by the United States, Great Britain, and Germany, the United States producing 39 per cent. of the total, or nearly as much as Great Britain and Germany together.

The extent of our industrial development may be better appreciated when it is realized that all but about four per cent. of our tremendous coal production is used in this country.

Rate of Increase of Coal Production

Tons of 2000 lbs.



The rate of increase in coal production by the three principal coal mining countries has been as follows:

	1870	1890	1912
Germany	37,500,000	98,400,000	282,400,000
Great Britain	123,700,000	203,400,000	306,000,000
United States	33,000,000	157,800,000	534,500,000

COAL-PRODUCING STATES

Altho it has been pointed out that our most extensive fuel areas are in the western part of the United States, industrial pursuits, the availability of oil, the convenience of natural gas, and other underlying causes have resulted in extensive coal production east of the Mississippi River and comparatively little production thruout two-thirds of the total area of the United States, as shown by the following table of production and use of coal by the different states:

Production and Use of Coal by States
(1915)

	Produced (Short tons)	Used (Short tons)
Anthracite:		
Pennsylvania	89,000,000	23,300,000
New York	....	20,800,000
New England	....	13,800,000
New Jersey	....	8,400,000
Illinois	....	3,300,000
Wisconsin	....	1,700,000
Minnesota	....	1,700,000
Maryland and District of Columbia	....	1,500,000
Remaining 30 states	....	4,400,000
Bituminous:		
Pennsylvania	158,000,000	65,500,000
West Virginia	77,200,000	6,200,000
Illinois	58,800,000	40,000,000
Ohio	22,400,000	22,400,000
Kentucky	21,400,000	5,200,000
Indiana	17,000,000	16,100,000
Alabama	14,900,000	7,500,000
Colorado	8,600,000	5,100,000
Virginia	8,100,000	4,300,000
Iowa	7,600,000	6,900,000
Kansas	6,800,000	3,200,000
Wyoming	6,500,000	600,000
Tennessee	5,700,000	3,600,000
New England	....	20,500,000
Michigan	1,200,000	10,300,000
Missouri	3,800,000	7,700,000
Wisconsin	....	7,700,000
All other states	24,600,000	57,100,000

Of the individual states, with the exception of West Virginia, those producing coal are the largest users, 33 per cent. of the 1915 output of bituminous coal being used within the states producing it.

USES OF COAL IN THE UNITED STATES

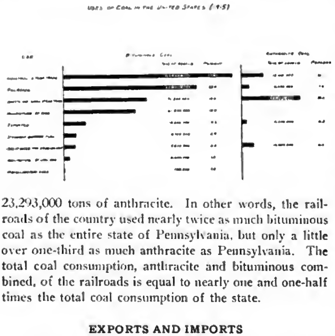
In the main, anthracite is used for domestic purposes and bituminous for industrial purposes.

The largest users of coal are the industrial steam trade, requiring over 30 per cent. of the mine output; the railroads, requiring about 24 per cent.; domestic and small steam trade—heating dwellings, apartment houses, hotels, office buildings, and heating and steam raising in small power plants—requiring 23 per cent. It is thus seen that even in normal times (1915) these three demands call for 412,000,000 tons, or 77 per cent. of all the coal mined in the United States.

Uses of Coal in the United States
(1915)

Use	Bituminous		Anthracite	
	Short tons	Per cent.	Short tons	Per cent
Industrial steam trade	143,800,000	33.0	18,800,000	21.1
Railroads	122,000,000	28.0	6,200,000	7.0
Domestic and small steam trade	71,300,000	16.0	50,000,000	56.2
Manufacture of coke ..	61,800,000	14.0		
Exported	18,800,000	4.2	4,000,000	4.5
Steamship bunker fuel	10,700,000	2.4		
Used at mines for steam and heat	9,800,000	2.2	10,000,000	11.2
Manufacture of coal gas	4,600,000	1.0		
Miscellaneous uses	700,000	0.2		

It is interesting to note that the railroads used 122,000,000 tons of bituminous coal and 6,200,000 tons of anthracite, and that the great industrial state of Pennsylvania used 65,541,000 tons of bituminous coal and 23,293,000 tons of anthracite. In other words, the railroads of the country used nearly twice as much bituminous coal as the entire state of Pennsylvania, but only a little over one-third as much anthracite as Pennsylvania. The total coal consumption, anthracite and bituminous combined, of the railroads is equal to nearly one and one-half times the total coal consumption of the state.



EXPORTS AND IMPORTS

Contrary to popular belief, the amount of coal exported is very small. In 1915 our coal exports amounted to only 22,700,000 short tons, which was 13 per cent. more than for 1914, but 8 per cent. less than for 1913. During these years Canada took from one-half to three-fourths of the exported coal. The total exports amount to only about 4 per cent. of the total coal production.

As pointed out by the United States Geological Survey: "The noteworthy features of the export trade in 1915 were the increasing demand thruout the year from Europe and South America, and in the latter part of the year the scarcity of vessels in which to ship coal to these countries. If the supply of vessels had been adequate, the exports undoubtedly would have been much greater."

Our importations of coal are small, amounting to about one-third of one per cent. of the total production. Practically all importations are to the New England states, the northwestern states, and California, due largely to the accessibility of Canadian coal and local transportation facilities.

HOW LONG WILL THIS WONDERFUL COAL SUPPLY LAST?

The use of coal as the chief source of fuel is comparatively new. With the possible exception of a few European countries, the forests were depended upon for fuel until within fifty or seventy-five years. Altho the draft upon our coal supply has just begun, it is time for us to realize that on account of the abundant supply and wide distribution of our fuel resources, on account of our relative freedom from large areas of congested population, and on account of our careless indifference to efficient utilization, we have neglected far too long the serious consideration of problems upon which hinge many of the possible activities of future generations.

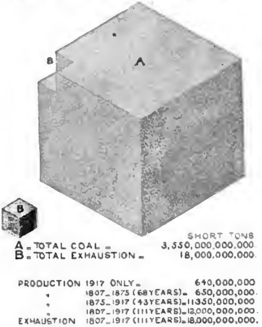
The unrestricted use of our better grade fuels and the ruthless waste and neglect of fuels that should be of real commercial value are phases of our national extravagance that are little short of appalling.

In attempting to estimate the probable life of our coal supply it is necessary to determine (*a*) the draft we have already made upon the original supply and (*b*) the rate at which this draft is being made.

In a little over one hundred years we have taken from the mines to the close of 1917 something over 12,000,000,000 tons. If we assume the usual loss of one-half ton for every ton mined, the total exhaustion has amounted to 18,000,000,000 tons, which is one-half of one per cent. of the original available supply lying at depths not exceeding 3000 feet. Packed as densely as it lies in the ground, and remembering that the original supply in the storehouse would make a pile whose length, breadth, and height would be eight miles, the portion drawn away or exhausted to date would be represented by a slice eight miles long and eight miles wide and only 0.04 mile (210 feet) high.

If the consumption for the past one hundred years could be taken as a basis, we might reasonably expect our coal supply to last some 20,000 years, but we must remember that we only began to use coal a little over one hundred years ago and it takes the total production of the first sixty-eight years (from 1807 to 1875) to equal the production of the single year 1917. If for all future time we were to mine coal at an annual rate just equal to that of 1917 (about 640,000,000 tons), with an allowance for unpreventable waste, then the coal supply should last 4000 years, but it is well known that in 1917 the demand was greater than the supply, and there is ample evidence to show that for years to come the demand will be an

TOTAL AVAILABLE COAL IN THE UNITED STATES AND EXHAUSTION TO CLOSE OF 1917.


B
A
B
SHORT TONS
A - TOTAL COAL - 3,550,000,000,000
B - TOTAL EXHAUSTION - 18,000,000,000.
PRODUCTION 1917 ONLY - 640,000,000
" 1807-1875 (68 YEARS) - 650,000,000.
" 1875-1917 (43 YEARS) - 11350,000,000
" 1807-1917 (111 YEARS) - 12,000,000,000.
EXHAUSTION 1807-1917 (111 YEARS) - 18,000,000,000.

ever-increasing one. An examination of our average annual coal production by decades since 1807 shows with what rapidity the rate of consumption is growing.

Average Annual Production of Coal by Decades from 1807 to the Close of 1917 (111 Years)

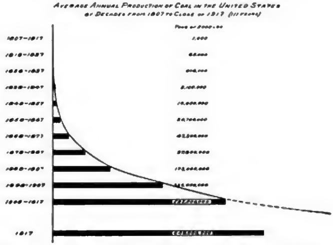
	Short tons
1807-1817	1,000
1818-1827	65,000
1828-1837	608,000
1838-1847	3,100,000
1848-1857	10,000,000
1858-1867	20,700,000
1868-1877	47,300,000
1878-1887	97,800,000
1888-1897	173,000,000
1898-1907	333,000,000
1908-1917	525,000,000

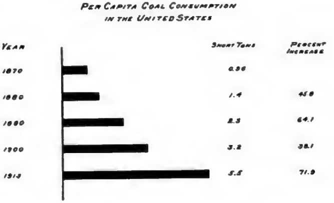
Campbell* points out that if the acceleration shown by the figures for coal consumption by decades be continued until the coal is completely exhausted, the supply will probably not last one hundred years. He says, however: "The true life of our coal fields probably lies between these two extremes, and the probability is that it will be nearer 100 than 4000 years."

Of equal significance is the increase in our per capita consumption of coal, shown by the following table:

Year	Short tons	Percentage Increase
1870	0.96	
1880	1.4	45.8
1890	2.3	64.1
1900	3.2	39.1
1915	5.5	71.9

Far more serious than the general drain upon all of the fuel resources of the country is the extravagant use of our highest grade material. The very best coal in the storehouse—the semi-bituminous of the eastern Appalachian field—amounts to a very small percentage of the coal resources, and it is this high-grade steaming coal that we are using with extravagant recklessness and without thought of the future. As E. W. Parker recently said in an address at The Franklin Institute: "We are rapidly consuming the cream and leaving the skimmed milk."





Before discussing the apparent coal shortage and serious fuel inconveniences of 1917, let us see what other natural fuel resources we possess.

PEAT

In the swamps and bogs of the Northeastern states, of the states near the Great Lakes, and along the south Atlantic coast are large deposits of partially decomposed vegetable matter or peat. Commercially dry peat has a fuel value per pound equal to only about one-half the value of the higher grade coals, but nearly, if not quite, equal to the lower grade coals, or lignites. From the standpoint of by-products, peat, perhaps, offers a more enticing field than the majority of coals.

Peat has been used for centuries in Europe as a domestic fuel, but not until within the past decade has it reached any importance as a fuel for power plants in competition with coal and lignite. Altho considerable peat is now mined in the British Isles, the greatest developments in the use of this fuel have been in Germany, Norway, Sweden, and Russia, the amount mined in Russia alone amounting to several million tons annually.

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* "The Coal Fields of the United States," United States Geological Survey Professional Paper 100-A.

The estimated deposits of the United States amount to about 13,000,000,000 tons of air-dried peat. Altho this amount seems small when compared with our coal and lignite deposits—amounting to only one-half of one per cent. of these deposits—yet the available amount is equal to the total tonnage of coal mined in this country in the past one hundred years. It should be noted that peat is found largely in states possessing no coal, which may prove an important factor in the ultimate solution of power distribution. Inasmuch as peat can be of no immediate service in our present fuel troubles, the discussion of this resource will be dismissed with the statement that within a comparatively few years peat will be highly valued in this country, not only as a fuel, but for other commercial purposes for which it seems admirably adapted and for which it is now being used in several European countries.

PETROLEUM AND NATURAL GAS

We are all so familiar with the demands for and the use of coal and see such extensive shipments moving in all directions as we travel that few of us appreciate the enormous value of two other fuel resources with which this country has been richly endowed—petroleum and natural gas.

An appreciation of the value of these products may be had from the following table of the value of the mineral products of the United States in 1913:

Coal	$760,000,000
Iron	458,000,000
Petroleum	237,000,000
Copper	190,000,000
Clay products	181,000,000
Cement	93,000,000
Gold	89,000,000
Natural gas	88,000,000
Stone	84,000,000
Silver	40,000,000
Lead	38,000,000
Zinc	38,000,000
All others	149,000,000

Third in the list stands petroleum, being surpassed only by coal and iron; and the annual value of natural gas is practically equal to that of gold.

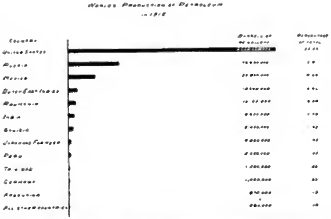
These three products—coal, petroleum, and natural gas—make up nearly one-half the total value of all our mineral products.

Of course, petroleum has other important uses outside of its demand in the field of fuels.

The position of the United States in relation to the world's production of petroleum is even more marked than its relation to the world's production of coal, nearly two-thirds of the total annual production of petroleum coming from this country.

World's Production of Petroleum *

Country	Production in 1916		Total production from 1857 to 1916, inclusive	
	Barrels of 42 gallons	Percentage of total	Barrels of 42 gallons	Percentage of total
United States	[a] 300,767,158	65.29	3,917,328,402	60.46
Russia	[b] 72,801,110	15.81	1,763,583,017	27.22
Mexico	39,817,402	8.64	163,087,779	2.52
Dutch East Indies	[c] 13,174,399	2.86	162,174,312	2.50
Roumania	[b] 10,298,208	2.24	140,310,595	2.16
India	[d] 8,228,571	1.79	89,820,956	1.39
Galicia	6,461,706	1.40	142,494,206	2.20
Japan and Formosa	2,997,178	.65	33,166,800	.51
Peru	2,550,645	.55	19,344,868	.30
Trinidad	[d] 1,000,000	.22	3,819,430	.06
Germany	995,764	.22	14,957,097	.23
Argentina	870,000	.19	1,903,121	.03
Egypt	411,000	.09	1,759,936	.03
Canada	198,123	.04	23,907,197	.37
Italy	43,143	.01	397,000	0.2
Other countries	[d] 25,000		889,513	
	460,639,407	100.00	6,478,944,229	100.00



a Marketed production. b Estimated in part. c Includes British Borneo. d Estimated.

A comparison of the production and value of the petroleum marketed in the United States in 1915 and 1916 shows:

	1915	1916	Per cent increase
Quantity (barrels of 42 gallons)	281,104,104	300,767,158	7.0
Average price per barrel	$0.638	$1.100	72.5
Total value	$179,462,890	$330,899,868	84.5

From the beginning of the petroleum industry in the United States to the close of 1917 this country produced approximately 4,250,000,000 barrels, or about 60 per cent. of the entire production of the world for this period.

FUTURE SUPPLY OF PETROLEUM

According to most careful estimates of the United States Geological Survey, the probable total original petroleum resources of the country amounted to over 11,000,000,000 barrels, of which the exhaustion to the close of 1915 amounted to over 3,600,000,000 barrels, leaving for possible future production about 68 per cent. of the original supply, or some 7,600,000,000 barrels.

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* United States Geological Survey.

If we assume a lake 100 feet deep and one mile wide, the length of the lake corresponding to the estimated total original petroleum resources would be over 22 miles. The exhaustion means that we have cut off more than 7 miles from the length of the lake and have left the equivalent of a lake 15 miles long, 1 mile wide, and 100 feet deep.

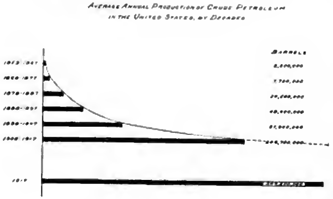
The petroleum fields of the United States are known as the Appalachian, the Lima-Indiana, the Illinois, the Kansas-Oklahoma, the North Texas, the Northwest Louisiana, the Gulf Coast, the Colorado, the Wyoming-Montana, and the California fields.

Altho the draft upon some fields has been but a small percentage of the available resources, notably only 2 per cent. exhaustion for the Wyoming-Montana field and 8 per cent. for the North Texas field, and altho the exhaustion for all fields combined amounts to 32 per cent., the proportion left in some fields is very small, the exhaustion of the Appalachian field having been 70 per cent. and of the Lima-Indiana field 93 per cent.

As in the case of the coal resources, the alarming point is the rapidly increasing rate of exhaustion, as shown by the following table:

Average Annual Production of Crude Petroleum in the United States, by Decades

Decade	Barrels (42 gallons)
1859–1867	2,200,000
1868–1877	7,700,000
1878–1887	24,500,000
1888–1897	48,600,000
1898–1907	97,900,000
1908–1917 *	246,700,000



On the basis of a future constant consumption equal annually to the estimated 1917 consumption of 344,177,000 barrels, the estimated available reserves of 7,629,000,000 barrels would last only about twenty-two years, and with an increasing consumption rate per decade equal to from two to two and a half times the consumption for the preceding decade the depletion of our petroleum supply seems near at hand.

However, just as we become alarmed at the rapid exhaustion of our petroleum resources, information appears which indicates that there are wonderful mountains of oil-laden shales in the western states and similar shales in the east-central states, from which some 40 or 50 gallons of oil can be extracted per ton of shale. Similar processes have been carried on in Scotland for the past seventy years. The Colorado shales alone are estimated to contain some 20,000,000,000 to 30,000,000,000 barrels of oil, and for the Indiana shales estimates as high as 100,000,000,000 barrels of oil are reported. These figures indicate that our shale oil resources are enormously greater than our original petroleum resources.

USES OF PETROLEUM

There are two general uses of petroleum—for refining purposes and for fuel.

In 1915, 227,540,000 barrels, or 82.5 per cent. of all the petroleum marketed from the United States fields, went to the refineries and 48,860,000 barrels, or 17.5 per cent. of the total, were used for fuel.

In addition, some 16,000,000 barrels of crude oil were imported from Mexico, largely for fuel purposes.

In New England petroleum is gaining ground as a fuel for many industries and even for domestic heating. Its use in the industries in other sections of the country is well established.

The railroads are the largest consumers for fuel purposes, having consumed 36,648,000 barrels in 1915.

Its use as fuel in the navy amounted to 1,120,000 barrels for the fiscal year ending June 30, 1916, and the United States Geological Survey estimated the requirements of the navy for the fiscal year 1916–17 as at least 1,300,000 barrels.

GASOLINE

Altho gasoline is not one of our natural fuel resources, its importance as a fuel warrants a brief consideration of its value. The Census Bureau Press Bulletin, February 10, 1916, shows the total quantity of gasoline produced in the United States in 1914 to have been approximately 1,236,000,000 gallons, and for 1915 the United States Geological Survey states the quantity to have been 1,977,900,000, an increase of 60 per cent. Of this total gasoline production in 1915, approximately 96.5 per cent. was derived from crude petroleum, the remaining 3.5 per cent. coming from natural gas, but the quantity derived from natural gas is increasing very rapidly, having jumped from about 7,000,000 gallons in 1911 to 65,000,000 gallons in 1915.

NATURAL GAS

Natural gas, an ideal fuel, is found in twenty-three states from New York to California and from Michigan to Louisiana. In spite of extravagant waste of hundreds of billions of cubic feet and the tremendous demands upon the original supply, resulting practically in the depletion of the supply in Pennsylvania, Ohio, Indiana, and some other localities, the production in 1915 amounted to 628,579,000,000 cubic feet. As stated by the United States Geological Survey,* "the magnitude of this output . . . can perhaps be comprehended more readily by a realization of the fact that a single gas holder large enough to contain it would be one mile in diameter and 5.4 miles high."

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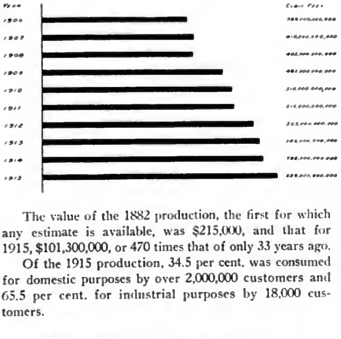
* Estimated for 1917 on basis of figures for first seven months of the year.

Unfortunately no definite information is available regarding the production of natural gas prior to 1906, as meters were not in general use before that date, the gas being sold at a flat rate per day or per month.

The approximate consumption from 1906 to 1915 is:

Year	Cubic feet
1906	389,000,000,000
1907	410,000,000,000
1908	405,000,000,000
1909	485,000,000,000
1910	510,000,000,000
1911	515,000,000,000
1912	565,000,000,000
1913	583,000,000,000
1914	592,000,000,000
1915	629,000,000,000

Annual Consumption of Natural Gas in the United States from 1906 to 1915



The value of the 1882 production, the first for which any estimate is available, was $215,000, and that for 1915, $101,300,000, or 470 times that of only 33 years ago.

Of the 1915 production, 34.5 per cent. was consumed for domestic purposes by over 2,000,000 customers and 65.5 per cent. for industrial purposes by 18,000 customers.

FUTURE SUPPLY OF NATURAL GAS

Any estimate of the possible future supply of natural gas is perhaps more of a guess than a definite calculation.

Wyer states that the average life of wells in Ohio is less than five years.

As several of the old wells are already exhausted, and as others are showing signs of exhaustion, the conclusion is that the supply cannot be counted upon for long, even tho new wells are located from time to time. According to some estimates, less than two decades will see the end of the natural gas supply.

WOOD

Our natural forests once covered one billion acres of ground, and in the short life of this country we have, thru indifference, greed, and ignorance, used or destroyed one-half of this magnificent original heritage.

The annual value of forest products is in the neighborhood of one and a half billion dollars, of which about one-fifth, or about $300,000,000, is for firewood.

The extent to which we use wood in this country is perhaps best shown by the fact that our per capita consumption is seven times that of Germany and ten times that of France. For years we have been cutting timber at a rate more than three times the rate of production.

1917 CONDITIONS

As we have had some inconvenience—in some cases real hardship—during the past weeks because our immediate demands for fuel could not be met, many rumors regarding the failure of our fuel resources have been current and many statements have been made regarding the failure of the mines to produce the needed coal supply.

Let us see just what the situation was at the beginning of 1917, or just prior to our entering the war.

The following points demand consideration:

1. As shown by the figures presented, we entered the year 1917 with

   (*a*) enough coal to last at least a few hundred years;
   (*b*) two-thirds of the original supply of petroleum;
   (*c*) enough natural gas to meet the normal demand for from ten to twenty years, altho failure of wells in certain districts—such as Ohio—has been most inopportune;
   (*d*) one-half of all the wood of the original forests.

Our present fuel problem is, therefore, not one of lack of supply at the source, but one of production, transportation, and distribution.

For obvious reasons we in Philadelphia are not just now seriously concerned with the petroleum, natural gas, and wood problems, but the coal situation comes home to all and calls for our special consideration. The pinch has been so definitely felt that it hardly seems possible that only a little over a year ago the production was greater than the demand.

What has brought about this sudden change in conditions?

1. Interruption of normal ocean transportation. The failure of ocean transportation threw back on the terminals vast quantities of freight, which in turn tied up cars and blocked the freight yards. Without ample cars for delivering new coal, the reserve supplies were soon exhausted and could not be replenished with any degree of regularity.

2. Impossibility of storing bituminous coal at the mines. Because of its composition, bituminous coal cannot

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* "Mineral Resources of the United States," 1915, Part II, p. 928, United States Geological Survey.

be stored in any large quantities, due to the danger of spontaneous combustion, but must be hauled from the mines as produced. With transportation cut off, production must cease. This is not true with anthracite, and in 1916 the anthracite mines had millions of tons in storage, but the severe winter of 1916–17 seriously reduced this surplus. The spring of 1917 found us then with no reserve coal supply and with transportation seriously handicapped. Then came our entrance into the war.

3. Increased industrial demands. Altho our fuel demands had been heavy prior to entering the war, the needs of the Government, of factories, and of munition plants became much more acute, many eight-hour plants jumping to twenty-four-hour service, and all at a time when car shortage and crowded terminals made delivery of coal from the mines impossible.

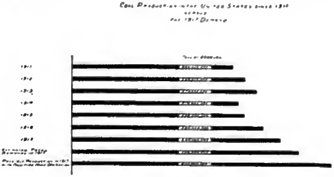
A popular notion prevails that the production of coal for 1917 was below normal, and that our inconvenience and suffering have been due to a failure on the part of the mine operators and miners to produce a reasonable amount of coal. An examination of the United States Geological Survey reports covering the comparative total production of bituminous coal in 1916 and 1917 reveals the following fact:

	Short tons 1916	1917	Per cent Increase
Total production of bituminous coal, January 1 to October 31 (10 months)	413,492,984	454,326,059	10.0

This is an increase of 40,833,075 tons over the production in the corresponding months of 1916.

Similarly:

	Short tons 1910	1917	Per cent Increase
Total production of anthracite, January 1 to September 30, (9 months)	49,928,000	57,778,000	15.7



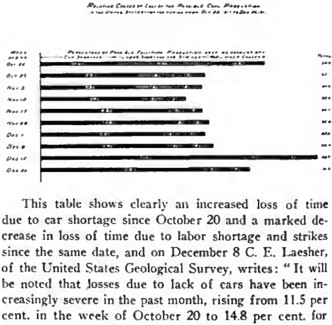
It should be noted that the year 1916 was a banner year for coal production in the United States, the bituminous coal output aggregating 502,500,000 tons. The bituminous production for 1917* has exceeded this amount by approximately 48,000,000 tons, or 9.5 per cent. Adding to this an estimated anthracite production of 90,000,000 tons for the year makes the total for 1917 in the neighborhood of 640,000,000,† as compared with a total of 590,000,000 for 1916.

In spite of this increased output for 1917, a reported shortage of at least 50,000,000 tons has frequently been published. This shortage is charged to the unusual demands resulting from increased industrial activity due to the entrance of the United States into the war.

But why, with such wonderful fuel resources, should there be a shortage? It is apparent that there is plenty of available fuel in the ground. It is also apparent that, if the mines be worked to full-time capacity, the total production could easily be made 800,000,000 tons per year instead of 640,000,000 tons.

Why have we not had the full-time output of the mines? A brief examination of the weekly reports on the production of bituminous coal compiled by the United States Geological Survey reveals at a glance the following facts:

Week ending	Percentage of full time	Percentage time lost	Percentage of time lost on account of Car shortage	Labor shortage and strikes	Mine disability	No market	All other causes	No cause given
Oct. 20 ..	65.8	34.2	11.5	15.1	2.6	...	0.1	4.9
Oct. 27 ..	74.9	25.1	14.8	5.9	3.8	...	0.3	0.3
Nov. 3 ..	75.4	24.6	14.5	5.7	3.6	...	0.3	0.5
Nov. 10 .	77.8	22.2	15.3	3.6	2.7	...	0.3	0.3
Nov. 17 ..	75.3	24.7	19.4	2.7	2.2	...	0.1	0.3
Nov. 24 ..	74.2	25.8	20.2	2.2	2.8	...	0.3	0.3
Dec. 1 ..	74.8	25.2	18.6	2.6	4.5	...	0.2	0.3
Dec. 8 ..	73.6	26.4	19.3	2.5	3.9	...	0.3	0.4
Dec. 15 ..	57.7	42.3	30.8	3.7	6.2	...	0.9	0.7
Dec. 22 ..	68.1	31.9	24.8	2.6	3.6	...	0.6	0.3



This table shows clearly an increased loss of time due to car shortage since October 20 and a marked decrease in loss of time due to labor shortage and strikes since the same date, and on December 8 C. E. Laesher, of the United States Geological Survey, writes: "It will be noted that losses due to lack of cars have been increasingly severe in the past month, rising from 11.5 per cent. in the week of October 20 to 14.8 per cent. for October 27, 15.3 per cent. for November 10, 19.4 per cent. for November 17, 20.2 per cent. for the week ending November 24. Inadequate transportation facilities thus remain overwhelmingly the dominant factor limiting the output of soft coal."

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* Estimated from eleven months' production (January 1 to November 30) of 502,100,00 tons.

† It is reported that Fuel Administrator Garfield estimates the 1917 production between 640,000,000 and 650,000,000 tons.

Again, on December 22, he says: "A study of these bulletins will reveal that the dominant factor limiting production is lack of transportation. So long as the soft coal mines of the country are idle from one-seventh to one-fifth of the time because there are no cars at the tipple, more laborers could add but little to the output. It should, however, be remembered that the railroads are already carrying more coal than ever before in the history of the country. With one exception, the production of bituminous coal during the month of November was the largest in any one month in the history of bituminous coal mining in America."

What is to be done? The coal is in the ground. It must be mined, it must be transported, it must be distributed. The necessary and natural steps seem to be:

1. Government regulation of the transportation facilities. (At this writing, December 27, 1917, the papers announce the welcome news "Government to Run Railroads.")
2. Government regulation of the distributing agencies.
3. Government regulation of the coal mines and the labor necessary to insure production.
4. Unless the coöperation of all who operate plants—from the small household heater to the great central station—and of all who use heat, light, or power from central sources is secured for a more economical and more efficient use of fuel to bring the demand well within the reasonable productive possibilities of the mines and the transportation possibilities of the railroad and boat lines, then must follow a division of all demands into two classes, essential and non-essential—essential to the winning of the war and the vital welfare of the nation—with a positive restriction of supply to the non-essential group, even to the point of prohibition, if necessary to the one purpose now before us.

To avoid the drastic action set forth in item 4 calls for active service on the part of all of us in one or more of the following fields: We should, without further delay

(*a*) See that all equipment used for developing heat, light, or power is in good condition—stop the leaks; repair the insulation.

(*b*) Use approved efficient methods of firing and operating—the majority of small plants are wofully inefficient.

(*c*) Use steam economically—eliminate the waste.

(*d*) Use electricity economically—eliminate all extravagance.

(*e*) Use gas economically—burn it only when needed.

(*f*) Use power generated by economical methods—shut down inefficient plants if power is available from more efficient and more economically operated plants.

(*g*) Confine the use of heat, light, and power to the dictates of reasonable comfort and real needs—eliminate luxuries, extravagant displays, and unnecessary service.

AFTER THE WAR—WHAT?

So bountiful has been our supply of fuel that we have in the past given little heed to the possibilities of the future, and our reckless waste and extravagance have been appalling. But now, at the first signs of the pinch of war, we are beginning to think—we have in a few months had a lesson in conservation which is a blessing in disguise. Let us see what our careless indifference has amounted to in the devastation of our fuel resources.

COAL

Defective mining methods have resulted in a loss varying from 50 to 150 per cent. of the coal production. Our general procedure has resulted in the flooding and caving in of mines from which only the better grades of coal have been taken, and the breaking up of the seams, thus making the removal of the coal by future generations not only expensive but so dangerous as to be prohibitive. Frequently 40 or more per cent. of the coal in a given mine could never reach the market. Even if only one-half ton of coal is lost for each ton marketed, which is common mining practice to-day, this wastage for the year 1917 would amount to over 300,000,000 tons, which if piled as ordinarily piled in bins or bunkers would be equivalent to filling Franklin Field with a column six miles high.

Another extravagant neglect has been our failure to recover the by-products in many industrial uses of coal, as, for example, the use of the bee-hive coke oven, resulting in the annual loss of tens of millions of dollars.

Not only must we use our coal efficiently, but we must use grades not now considered commercially available—high ash fuels, bone coals, culm, slack, lignite, and peat. The efficient use of these fuels for producer gas manufacture has already been successfully demonstrated by the United States Bureau of Mines.

PETROLEUM

The necessity of petroleum in the successful prosecution of the war is imperative. Petroleum has become the principal fuel of the navies of the world. All recent orders for battleships and destroyers by our navy have specified oil as fuel. The lubricants derived from petroleum are essential to the efficient operation of all types of machinery. Gasoline is required for the operation of automobiles, motorcycles, auto trucks, airplanes, armored cars, and motor boats. Our extravagant use of gasoline should be checked not only now but for all time.

The United States Bureau of Mines puts the daily production of gasoline at 6,849,000 gallons and the daily careless waste thru motor cars, due to leaky carburetors, motors running idle, waste in garages and thru tank wagon losses at over 600,000 gallons per day, or nearly 10 per cent. of the total production. This waste is over 60 per cent. of the estimated war needs, which amount to 959,000 gallons daily, and the Bureau estimates that by a little caution on our part about using our pleasure cars needlessly we can save an additional one and three-fourths pints daily per car, or nearly 900,000 gallons, which if added to the 600,000 gallons now carelessly wasted makes 1,500,000 gallons daily, one and a half times our total war demand.

NATURAL GAS

Our ruthless waste of our most perfect natural fuel is beyond all comprehension.

When natural gas was first used tremendous quantities were lost thru inability to cope with the high pressures when the reservoirs were tapped. Vast quantities have been lost thru the indifference of those interested in securing petroleum, but not concerned about natural gas, and the gas from the wells has been purged in order to get the oil. As great as have been the losses from these two sources, the really appalling loss has resulted from burning wells. Hundreds of millions of cubic feet have thus been destroyed daily. For twenty years one well blew forth wasted gas, the aggregate value of which was $3,000,000. As late as 1913, in the Oklahoma field alone, the yearly waste amounted to 100,000,000,000 cubic feet, and not ten years ago I. C. White, in speaking of the conditions in West Virginia, said: "At this very minute our unrivaled fuel is passing into the air from uncontrolled gas wells, from oil wells, from giant flambeaus, from leaking pipe lines, and the many other methods of waste at the rate of not less than 1,000,000,000 cubic feet daily, and probably more."

For years the waste was equal to the amount utilized, and frequently reached the equivalent of the loss annually of 20,000,000 tons of coal, or the destruction of a 38-ton car of coal every minute of every 24-hour day for the year.

FORESTS

The waste of our forest products that might be utilized for fuel is enormous. In the lumbering operations the loss is put at one-quarter of the timber cut, and at the mills at least another quarter of the original forest output is sacrificed, and by the time the lumber is in the finished product fully 60 per cent. of the forest growth has been ruined for commercial use. Some of this refuse is used for fuel, but a large portion is dissipated, and much is set on fire in order to get rid of it.

No doubt many of you have not forgotten the huge piles of sawdust and edgings burning at the mills day and night thruout the year.

A second tremendous waste results from our turpentining methods. The life of the boxed trees is but a few years at most, and many are blown down and left to decay in the forest.

The third and most serious loss is due to forest fires, whose annual devastation has often amounted to fifty or more millions of dollars.

UTILIZATION OF WATER RESOURCES

When our mineral fuel resources have been used they are gone forever. The supply is limited. We must reform. We must so discipline ourselves that we mine only such amounts as we really need and can efficiently use, and, to the end that these fuel resources be conserved to meet the needs of future generations, we must develop our water resources.

The surprising effect of hydro-electric power upon fuel conservation is shown by the recent electrification of portions of the Chicago, Milwaukee and St. Paul Railroad in Montana. Two divisions have been electrified, and a third will be in a few months.

As stated by the *Electrical Review*, October 20, 1917: "The conservation of 200,000 tons of coal and 800,000 barrels of oil per annum in the operation of about 725 miles of railway makes a considerable impression in the fuel supply problem. It is 18 per cent. of the fuel saving effected by the reduction of passenger train service on all the railroads of the United States for the year."

TRUE CONSERVATION

Besides the efficient operation of plants for the production of heat, light, and power, true conservation means that:

1. We must use efficient modern methods for mining coal.
2. We must recover the by-products from coal whenever possible, and eliminate extravagant methods of making coke.
3. We must use grades and kinds of coal not now regarded as commercially available.
4. We must not use petroleum as fuel when other satisfactory fuels or other economical sources of power are available, or we will deprive future generations of the valuable and necessary products derived from petroleum.
5. We must check the needless, thoughtless waste of gasoline.
6. We must check the useless flow of natural gas from the wells and the terrible destruction caused by burning wells.
7. We must reduce the waste in cutting timber and manufacturing lumber and must utilize the unavoidable waste for fuel.
8. We must reduce fire losses in our forests.
9. We must reforest large areas and must substitute other products for timber.
10. We must generate power close to the sources of supply—at the mines—transmitting electrical energy instead of transporting the coal.
11. We must take advantages of our wonderful water resources.

This war is a terrible thing, but thru its many wholesome lessons we should be brought to a realization of our past ruthless waste and extravagance, and should for generations to come remember that fuel as well as food is essential to our welfare and protection. "Don't waste it."

COMPRESSION RHEOSTATS*

By ARTHUR H. ALLEN

THERE is practically only *one type of compression rheostat* on the market at the present time, so this paper will have special reference to the rheostats commercially known as the Allen-Bradley type.

In order to bring out more clearly the difference between the compression type and the older forms of sectional resistance rheostats, it will be well to consider some of the fundamental principles pertaining to rheostats.

What is a rheostat? A rheostat is a combination of units of resistance, with means for varying this resistance.

What is resistance? Resistance is a property of the form and material of the circuit as a measure of the force required to maintain unity current. I make this statement to emphasize that resistance is really a form of the consumption of energy.

Rheostats are made up of one or more units of resistance; as the consumption or conversion of any energy produces heat in some form, it necessarily follows that heat is engendered by the action of the rheostat, no matter what its form is. This point is made because the question is frequently raised with one or the other types of rheostats, whether for field control or as a motor; starting it heats up. As can readily be seen from the above, it must necessarily heat up, and this applies not only to the old type of sectional resistance, but also to the compression type of resistance; as a matter of fact, their function would not be accomplished unless they did heat up. The question, however, is whether this heating up produces unsatisfactory results in regulation or in maintenance of the rheostats.

Rheostats are used with electrical apparatus, generators and motors, to control the field of each by throwing more or less resistance in series with the field or armature circuit.

The very old forms of rheostats, such as were in use twenty years ago, were almost wholly made up of iron wire in coils placed in wooden boxes, and these were arranged in series or in multiple series, according to the capacity desired in each resistance unit, which constituted part of the rheostat. By the movement of the handle these sections of resistance units were cut in or cut out one after the other.

Later, improvements were made assuming many different forms. Better wire was used for resistance purposes, wire that would not break so readily; or the coils, particularly in smaller sizes, were embedded in porcelain or other similar material. In larger sizes the grid resistance was used. In all these different types the same fundamental principle was employed, in the use of iron or composition wire or metal in some form, placed in a series or multiple series, constituting units of the rheostat. Of course, there are some forms of rheostats, like the water rheostat, but none of these special forms will be considered at this time.

The great objection to all the old types and forms of rheostats has been due to the fact that they were made up of wire or grid-iron resistance, which was easy to break, due to vibration; also to the sectional feature of this resistance, which meant that as one section after the other was cut in or cut out a more or less decided change was made in the resistance, and consequently a decided change of the current which the motor or generator received, due to difference of potential between segments. To show this graphically meant that there were jumps in current value as the handle passed from one section to another. These jumps and the extent of them depended upon the number of sections; the greater number of sections the more costly the rheostat. The result of these greatly changing current values meant a liability of sparking as the brushes of the rheostats passed from one section of the contacts to another, causing wearing of the brushes and contacts.

The compression type does away with many of the above objections, and it will be interesting to know of the developing features of this type.

Compression rheostats, deriving their resistance properties from imperfect contact of the elements of resistance units, were one of the early developments of the electrical art, the most common uses being the telephone transmitter and brush regulator, both employing carbon elements.

A theory of this varying resistance by contact is that it is due to the michrophonic distance between the electrodes or molecules; that is, the distance which one molecule can be moved away from the other without breaking the circuit. A very good illustration of the principle of this type is the water rheostat.

The most satisfactory substance for use as compression resistance is carbon.

Carbon has different forms, as you know: the diamond, graphite, and amorphous carbon. Of course, in the form of diamonds it cannot be used, for reasons to be given later. Amorphous carbon has not proved satisfactory, but graphite has.

Carbon possesses the following properties:

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* Presented before the Worcester Tech Club, February 7, 1918, at the Engineers' Club.

1. It possesses low internal and high contact resistance.
2. It is not readily oxidized.
3. It is absolutely imperishable.
4. It passes immediately from solid to gaseous state if raised to high enough temperatures, and, having no plastic or liquid state, will not weld.
5. It is not affected by moisture; not readily acted upon by chemicals; not subject to corrosion.
6. Its specific heat is high, and, when away from circulating air, will endure high temperatures approximating those of the electric arc.
7. Its temperature coefficient is negative.

It will readily be appreciated that there are marked advantages in the use of such a material for rheostats, if it can be put up in proper form for practical and reliable use.

The elements of construction of the compression rheostats consist of:

Carbon in the form of graphite discs treated with a suitable reagent to give a high surface resistance and to sustain the resistance while under high temperatures.

A steel tube closed at both ends, with a refractory cement lining in which the graphite discs are piled in a column, with a plunger thru the top, carrying the top graphite block, and thru which the column of graphite discs is compressed by contact with a bracket head.

The act of compression is performed by means of lever or a finely threaded screw-head and hand-wheel. The compression is exerted to approximately 200 pounds per square inch, and under these pressures a resistance tube of graphite discs gives the following various registers: No. 1 register 0.0000635 ohm in fifty-five different registers to 16.71168 ohms per joint.

Standard $1^1/_{16}$-inch tubes have a carrying capacity of thirty ampères, and the larger $1\frac{1}{2}$-inch and $1\frac{7}{8}$-inch tubes a carrying capacity of sixty ampères per tube. The tubes are multiplied and connected in multiple or multiple series to get greater capacities.

Resistance units for hand starters are figured for short-circuiting at 10 per cent. of line voltage on them and full load current. The range of resistance may be secured as high as 200 to 1 by selected graphite discs; but ordinarily a range of 100 to 1 is given.

Thru a link connected to the lines and compression and tension springs a wide range of easy adjustment can be secured.

The commercial forms of compression rheostats cover the whole field of hand starters, direct and alternating current; direct-current and alternating-current crane controllers, direct-current and alternating-current automatic starters, and battery charging rheostats.

The field that is not so readily covered by this type of rheostat is generator field rheostats and motor rheostats for control of speed by field resistance. The reason for this is because of the negative temperature coefficient peculiar to graphite and the limited surface for heat radiation. The apparatus is more strictly for intermittent duty. Briefly the following are the most distinctive advantages:

Change of resistance not due to cutting in and out specific units or elements of resistance, but rather a gradual change of the resistance element due to change of molecular contact of the graphite discs.

Radiating capacity of the rheostat is uniform, and the entire surface of the compression rheostat is always in circuit. It is also a fact that, except for that point at which the circuit is closed, and the point at which the resistance is shunted at maximum pressure, there are no perceptible increments of current flow; no sparking due to jump of current flow; saves the motor, due to more even flow of current; no blows to motor, due to quick inrush of current; no overdue strains; easier on generator or motor commutator and brushes and fuses, causing less trouble and repairs. Only limited number of segments in old type and only part in service if motor starts hard. As there is practically no sparking or arcing on the face plate of a compression type of rheostat, there is less wear and tear of the segments and contacts, and less fire risk.

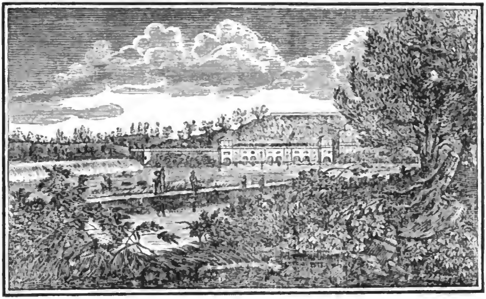
As the resistance tubes can be replaced very readily without taking down the rheostats, the cost of repairs and maintenance is very low.

Compression rheostats are not readily overheated, and, if so, there is no injury caused. Jarring is beneficial, therefore there is no trouble due to vibrations or crystallization.

The causes of trouble with a compression type of rheostat are reduced to a minimum. Tubes may burn out, due to excessive overheating or overloads, causing a short-circuit with the graphite discs, due to breaking down of the refractory cement lining of the tubes.

Trouble may result from improper installation; mounting the rheostats upside down, which, of course, cuts out considerable resistance by the weight of the tube and discs; improper adjustment or lack of adjustment of the spring tensions.

In time the surface resistance of the graphite discs will change, necessitating the renewal of the column. Under ordinary service a resistance charge will last for years and the cost of replacing is small, where with the old type the whole rheostat is probably scrapped. The above troubles are peculiar to the compression type, but, on the whole, it is contended that this type is much more reliable, costs less for repair parts and maintenance, will stand greater abuse, costs no more—in fact, less, on the larger sizes—and eliminates one of the objections to motor installations.



FAIR-MOUNT WATER-WORKS.

(Published about 1831 to 1835. Photographic copy of the outside cover of a book used for making entries in the year 1835. As the text refers to the cholera epidemic in Philadelphia, it appears to have been published later than 1831 or 1832.)

THE Fair-Mount Water Works may be considered as the last of a series of experiments to procure for the city of Philadelphia an adequate supply of pure and wholesome water. It was about the year 1797 that the deterioration of the water procured from pumps induced the City Councils to adopt a plan suggested by Mr. Latrobe of forming a reservoir on the east bank of the Schuylkill River, from which water was thrown by a steam-engine into a tunnel, and thence carried to another engine-house at the Centre Square, where it was to be again raised by a second steam-engine to an elevated reservoir, and so distributed in pipes throughout the city. Under many discouraging circumstances, the city government persevered in this work, until, in January, 1801, the water was distributed to the city. The cost of these works was nearly 700,000 dollars.

Ten years' experience satisfied every one that the supply thus obtained was entirely inadequate; and, in 1811, another plan was adopted. A reservoir was constructed at a point just above the one-arch bridge, and two steam-engines, which worked alternately, raised the water 105 feet into this reservoir. But the supply was still insufficient for the rapidly-increasing city; and, after expending 320,000 dollars in this second experiment, in 1819 the last and most successful method was determined upon and commenced by the appropriation of 350,000 dollars to carry it into effect.

A dam was thrown across the river, at the same point where the last works were erected. This dam is about 1600 feet in length, and, for the greater portion of its extent, runs diagonally up the stream until within a short distance of the western shore, when it runs at a right angle to join it. At this western end of the dam are the locks and canal of the Schuylkill Navigation Company. The city works are on the eastern shore of the river, and are constructed with a degree of elegance and durability that can scarcely be surpassed. Space for the works had to be obtained by blasting a solid rock, which here formed the bank of the river; and the gunpowder used in this operation cost no less than 12,000 dollars.

The mill-race is excavated out of the rock, which rises on its western side to the height of 70 or 80 feet, affording a substantial support to the reservoir above. The south end or wall of this race is also of rock, and its western side is formed by the range of mill-houses, which receive the water, by means of proper gates, upon the large water-wheels: the water then passes out into the river below the dam.

These wheels are at present six in number, and there are vacancies for two more. The wheels are generally 15 or 16 feet in diameter, and each raises from 1,000,000 to 1,500,000 gallons daily. The pipes through which the water is propelled into the reservoir are laid at the bottom of the mill-race, and thence extend up the face of the hill. The reservoir on the top of this eminence is very capacious; so that, in case of a freshet in the river, the wheels may be stopt for a time without depriving the city of its customary supply. Iron pipes conduct the water thence to every part of the city proper, and to nearly all the surrounding districts.

We may form some idea of the vast benefit conferred upon Philadelphia in the possession of these works by a statement of the following facts. When the steam-engines were in operation, the expense of procuring a daily supply of water amounting to 1,500,000 gallons was 30,858 dollars a year; whereas, at the present time, when there are usually five or six wheels in operation, furnishing 6,000,000 gallons in the warmest portion of the summer, the expense is less than 3000 dollars per annum. This abundant supply of water enables the city government to cleanse the streets and gutters twice or thrice in every week; the adjoining districts also imitate this example, so that nearly the whole of this large population participates in the consequent benefits. It is not unreasonable to attribute the exemption of Philadelphia from any serious epidemic sickness, and the slight visitation of cholera at a time when other places suffered excessively, to this copious supply of pure and wholesome water.

These works cost about 430,000 dollars; but this does not embrace the sums annually expended in improvement and embellishment, nor the expense of substituting iron pipes for the wooden ones in all parts of the city. Including these items, perhaps a million of dollars has been expended. But the citizens of Philadelphia are justly proud of these splendid works, and grudge not the expense bestowed upon them; whilst thousands of strangers annually visit the spot, and but very few are unwilling to acknowledge that it presents an unsurpassed combination of the beauties of nature and art.

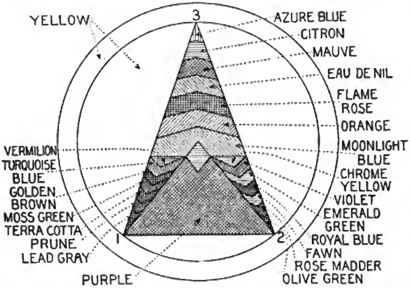
(Presented to the Engineers' Club of Philadelphia by Carl Hering, March, 1918.)

COLOR IN ILLUMINATION*

By BEATRICE IRWIN

OBSERVATION and experiment have led to the conclusion that there are three fundamental scales of color, which react respectively on our physical, mental, and nervous systems. These I have named the physical, mental, and spiritual colors. Each of these is divided in turn, in accordance with its affective values, into sedative, recuperative, and stimulant colors. Whether we are aware of it or not, color always falls within one of these three groups and always affects us in one of these three ways. These subdivisions of color are represented in the accompanying chart (Fig. 1).

Red has been called a stimulant, blue a sedative, and green an exhilarating color. I contend that red can be a sedative, blue a stimulant, etc., according to the composition of the red or the blue, or according to its combination with other colors. If we can determine and appreciate the psychological as well as the physiological value of a color we can utilize it to an extent hitherto unknown. This theory has been submitted to laboratory as well as other tests.



Once we realize that the terms red, blue, green, etc., are only symbols for long ranges of vibratory phenomena which we must classify and utilize with a new nicety and thoroness, we shall have taken the first step toward realization of the full value of color as an influence in our lives. If this new language of color is to conduce to the comfort of all, it will have to establish its credentials thru universal as well as individual channels, and it will have to prove its industrial as well as its esthetic and scientific value.

At last color is coming into her own thru many channels, and, while realizing their respective significance, I do not hesitate to say that one of the greatest opportunities for scientific color expression lies in the hands of the illuminating engineer, for if the physician and psychologist can determine the science of the affective value of color, the illuminating engineer can supply that light of any desired hue, and thru this opportunity he can develop a new field of achievement.

But in order that he may avail himself of this opportunity he must train his eye and his whole organism to this broader vibratory conception and realization of color.

The color-sense, like all senses, is dependent upon a definite but gradual education, and, while it is more developed in some than in others, it is certainly capable of coherence in all, and it is to the achievement of this coherence that the new science of color aims.

An increased color sensibility, with a lack of coherence, is what all color expression suffers from at the present moment. In this color language we have found a new voice, but we are trying to sing songs before we have formulated syllables—or practiced our scales. The students of color-science are thinking and speaking of color in the psycho-physiologic terms individual to itself which my chart provides, and which aim at a clearer understanding upon a hitherto vexed question.

In this century any message that claims to be universal must fulfil exacting and multiple conditions, because this is the glorious age of coöperation, of mental democracy, and of the intermingling of *industry, art, science,* and *religion*. History has never recorded any epoch in which there was such an alliance and interpenetration of activities, not for the purpose of individual enjoyment, but for the general welfare. I have traveled once and a half around this radiant world, and of all the countries visited America appears to me to be foremost in demonstration of this coöperative universalism. The theoretical philosophies and cautious enterprise of other countries pale before the ruddy and solid proofs of progress that are embodied in your vast cities, your expositions, your splendid libraries and colleges, and in your representative homes, which all proclaim the marvels of light and the longing for its further utilization and understanding thru this mobile and ardent medium of color. Surely then it is not only well but essential that we should employ some specialized classification of a phenomenon that we are expressing so freely.

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* Paper read before the Philadelphia Section, Illuminating Engineering Society, at The Franklin Institute, December 21, 1917.

For, fundamentally, this growing need and use of color, and the increasing number of persons who are explaining and demonstrating its life, are only so many statements of the fact that, having battled with Nature's coarser forces and expressed their conquest thru graven images of metal, wood, and stone, the race is now turning to the conquest of the finer forces which are collectively expressed in such words as light, electricity, vibration, and color.

This new and broader aspect of color is finding more numerous adherents among psychologists, artists, astronomers, and craftsmen.

Turning now to color in illumination, we may premise that the principal purposes of illumination are "Utility," "Beauty," and "Hygiene." Each of these may be promoted thru a discerning and discriminating use of color, and the demand for color in illumination is a proof of our need for specialization in this application of light. I can foresee the creation of harmonic and mobile installations that will vie with Nature's rhythmic distribution of light, which is so marvellously adapted to man's mobile requirements, for it is contrary to cosmic law that the human organism, so pulsating and plastic in its essence, should be subjected to a monotonous lighting. How would a plant be affected were it subjected to the same degree of light continuously?

Once the principles of color-science have been mastered, half a dozen decorative schemes can be created by the use of adjustable screens, or textile linings for globes, but these linings should not fatigue the eye with useless design. In lighting, as in other channels, the liberation of color from conventional design is an essential point, because our perception of vibratory color values is impeded by our perception of form. In my decorative work I advise diffused semi-indirect lighting for the first or general installation, and either lamps, side brackets, or globes sunk in the wall for what I call special or color installation. Let us consider these installations in detail.

The general installation may with esthetic propriety lay more stress upon its fixtures which have a permanent decorative value in the interior, but these fixtures should also be selected in harmonic correspondence with general color environment. How often one sees a charming little room vulgarized by the introduction of a massive, pretentious brass or bronze lamp that is utterly incongruous with either the volume of light generated or the textiles illuminated! My attendance at various electric exhibits has shown me that considerable attention is still needed in this accessory branch of illumination. The general installation should be tinted either to heighten or lower the whole vibratory color values of the room, but this tinting should be delicate and unobtrusive, its aim being to create atmosphere rather than to focus attention. This is the function of the second, or color, installation, and in this case the fixture should be as nearly invisible and as unimportant as possible, so that the impression received may be from the color itself, and it is best to express such light motifs in the natural recesses of shadow, or, if such recesses do not exist in a room, we can create them by various artificial means. For this purpose I have used masses of silk (which has a high reflective value) around special installations.

The sunken globes to which I have referred were also originated by me for the purpose of creating mobile color expression in the interior. Set in the wall under glass ledges, their brilliance gives life to the hollowed niche in which is set the color screen which they illumine. These screens, which I am painting on parchment, are varied in form, can be changed at will, and are restful and effective. The electric current operated in connection with them can have several degrees of intensity, which further affects the color values of these screens. In large halls or ball-rooms such effects could be used with great decorative value in conjunction with pools of colored light in the floor under glass translucences.

When people become more acquainted with the hygienic value of colored lights possibly they may insist on these installations with as much stress as they now lay upon ventilation. Compare our modern windows with the slit-like apertures of the Middle Ages, and notice how the race demands light as it progresses. Now, from quantity we are advancing to quality, and color-science can teach us to differentiate in this all-important question of the degree and nature of the lighting system in our dwellings. Unless in stores, where matching is a necessity, the daylight system of illumination is a source of eye-strain and nervous exhaustion. Just as inadequate lighting is responsible for eye-strain in some cases, so over-lit rooms are responsible in other cases for more neurasthenics than the average physician is aware of. Color-science suggests that every building shall have two systems of illumination for alternate, but not simultaneous, use. The first installation shall fulfil practical demands, preserving the general conditions necessary for ocular hygiene, but avoiding any pronounced color or decorative effects. For example, in a dining-room or library, for general purposes, there should be a discreetly tempered luminance graded harmonically to the vibratory color values of the room, but in addition to this there should be decorative motifs of light which have a definite color purpose and value, and this installation could be operated as occasion demands.

To preserve color-balance a room worked out in sedative color scale should have a recuperative value in its first and stimulant values in its second installation. Do you notice that I purposely avoid the terms "utilitarian" and "decorative," because I feel so strongly that in reality these terms are one, the greatest use always underlying the greatest beauty, the needless distinction between these terms being accountable for most of our errors in color expression.

(Continued on Page 208)

NOTES ON FIRE PREVENTION*

By H. P. WEAVER

THE following is a brief *résumé* of the thoughts presented at the meeting above noted:

Fire prevention should properly have a place in the consideration of the safety engineer. Fires, in the main, are accidents, and, quite aside from property destruction, often result in injuries or loss of life. In addition to this, the actual loss in property destruction and in indirect cost to the nation can be shown to amount to about $400,000,000 or $500,000,000 per year. In these days of billion-dollar expenditures, this may not be regarded as an impressive sum, but nevertheless it does involve a problem well worth the most careful consideration. It is a fact that the fire loss per capita in this country is eight or ten times as great as in some of the European countries. It must be recognized that insurance does not pay for fire loss, but merely distributes it.

What are the reasons for this apparently extravagant waste of material and human resources? First, let us consider the underlying and fundamental reasons. One of the most prominent underlying of these is liberty. The American citizen prizes very highly his liberty, but he is inclined to interpret it as freedom from restriction of any sort. This attitude leads to the feeling that the citizen should be permitted to continue the existence of conditions in his own premises which may be a danger not only to himself but to his neighbors, and he should brook no interference in this from the constituted authority. If he chooses to build a bonfire in his back yard on a windy day, that is entirely his affair, even tho it may seriously endanger the property of his next-door neighbor. He does not wish to be told by the fireman on inspection detail to clean out his basement, as he feels that his basement is his own domain and should be subject to no one's control. Consequently the maintenance of fire conditions at a point reasonably free from even the most commonplace hazards is difficult.

Another underlying cause is the great American hustle. We take pride in our speed, in our devotion to the main chance, and our ability to drive directly to the desired object without diversion of thought or energy to side issues of any sort. Fire prevention is perhaps a side issue. Therefore we have little time or thought for anything of this sort which may not show a direct profit on the books and which we may avoid if we have good luck over a period of years.

A third underlying reason is the wide prevalence of highly combustible construction in this country. Altho the frame building for manufacturing purposes is gradually disappearing, nevertheless great numbers of buildings with incombustible walls have wooden interiors which, in conjunction with combustible contents, furnish all the setting necessary for practically a total loss. The frame building is still a large factor in the dwelling-house phase of the question, and this, altho not so directly related to business and industry, is not a subject to be entirely overlooked. In the older European countries combustible construction is much more rare, and this in itself is a potent factor in keeping down serious fire loss.

We could profitably spend a great deal of time discussing the specific causes of fire. It might not be amiss to regard the whole problem as divided into various lines of defense. Let us call the first "fire cause." In this line the object is to prevent the origin of fire, so far as it is possible to do so. Those specially trained in such matters can detect and recognize many fire causes in seemingly innocent conditions. The next line of defense may be designated as "fire extinguishing"; that is, if fire starts despite the precautions to prevent it, then proper facilities should be available to put it out. Here, also, careful analysis of conditions and of the adaptability of specific forms of protective equipment is necessary. Suppose, then, that these two lines of defense fail us and we must fall back on a third. This we may call "fire spread." Our properties should be divided by fire walls and otherwise separated by proper physical barriers so that if fire gets entirely beyond control it will not destroy a large amount of property, but will reach only a certain limited, segregated area, in order that the actual property loss may be kept within bounds and so that, if possible, the manufacturing or other processes carried on may continue in the remaining units until such time as the destroyed sections can be replaced.

These, then, are the three primary lines of defense, and under each one may be discussed a variety of specific subjects.

There are, for instance, questions of care of oils and inflammable materials. Electrical equipment must be properly installed and maintained. Stoves, furnaces, steam pipes, and other sources of heat must be reasonably safeguarded. Cleanliness must be maintained at a high standard. Rubbish, refuse, and sweepings must be cleaned up regularly and removed promptly. Care must be taken to see that smoking and the use of matches are limited to sections where the hazard is at a minimum. The many special hazards incidental to the elaborate manufacturing processes carried on these days must be studied and properly safeguarded. Care must be taken to see that fire walls are complete and adequate and that any necessary openings are protected by suitable fire doors or other equipment, making sure always that such things are in proper working order. Vertical openings for stairways, elevators, or other purposes must be so arranged that they will not form flues for the quick transmission of fire from lower to upper stories. Study must be made of the dangers of exposing exterior structures which may be the means of communicating fire from the outside. The situation must be reviewed to make sure that proper protective equipment of the many kinds available is selected to meet the existing conditions. Not only must it be proper in amount, but it must be carefully selected for design, workmanship, material, arrangement, accessibility, etc. Watchmen must be selected, and they should be watchmen and not fossils. Alarm systems must be installed, fire brigades must be organized and trained, and many other things too numerous for discussion at this time must be reviewed and scrutinized most carefully.

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* Read at meeting of the Philadelphia Safety Council, January 15, 1918, at the Engineers' Club.

Where does the responsibility for the proper handling of these many problems rest? First, there is the responsibility of the public. Cities must maintain proper fire departments for the prevention and extinguishing of fires. Needless to say, fire departments should be free from political manipulation. Building departments must be looked to for proper supervision of building construction and proper structural maintenance of buildings already in existence. Building codes must be suitable and must be enforced. Here, again, politics should be kept strictly on the outside. We must look to the city likewise for proper water supplies, even to the extent of high-pressure systems in congested districts. Upon the city also devolves the duty of developing a tangible, practical scheme for the city's growth in such a way that conflagration possibilities will be gradually reduced, if not eliminated.

From state authorities must be expected the appointment and moral and financial support of a state fire marshal, together with legislation and funds necessary to put in force proper fire precautions thruout those sections under the jurisdiction of the state in particular.

Education of the public is to be expected thru various commercial bodies, such as Chambers of Commerce and, beginning still further back, thru the schools themselves.

The larger and more far-sighted corporations are doing a vast amount of work in the reduction and control of fire hazards in their own properties. This alone is one of the most important factors in the treatment of the general fire hazard thruout the country. These concerns bear in mind particularly those phases which concern possible interruptions to the continuous operation of their business. Many interesting points arise in the study of this particular phase of the question. Just as a single example, can you imagine a way in which a modern plant could be more completely shut down, so far as production is concerned, than by destroying its source of power supply? Even a comparatively small fire at the proper point in the power system of a modern plant may cripple it seriously for a considerable period.

Then, last, but by no means least important, comes the individual himself. In the everyday dwelling there are almost invariably present many very obvious fire hazards which can be detected by persons not necessarily trained fire-protection engineers. When you go home to-night look over your own house from top to bottom and see how many genuine fire hazards you can find and how easily most of them will be eliminated. Consider the small bottle of gasolene, the metal polish which has combustible ingredients, the furniture polish rags which are liable to spontaneous ignition, the matches which are carelessly used, the gas fixtures so placed that window curtains can blow into them or so arranged that they can be swung into contact with woodwork or other combustible material. Look over that pile of rubbish in the basement and decide whether it could not be removed. If the ashes from your furnace are being removed in wooden boxes, do not let the sun set again until you have provided metal receptacles for them. Then, finally, consider how you would arrange for the escape of the occupants of sleeping-rooms in upper stories without going out into the halls, which are the first places to become filled with smoke and fire.

Bear in mind all of these things, and then remember the three primary lines of defense. Prevent the fire occurrence if possible, be equipped to extinguish it if it does occur, and arrange your property so that it cannot spread thruout the entire group. With these thoughts before you, see what you can do to reduce the national ash heap.

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SAMUEL T. WAGNER (A. S. C. E.)
WALTON FORSTALL (I. E. S.)
J. B. DOUGLAS (P. S. C.)
D. K. BULLENS (M. I. T.)
A. H. EHLE (S. A. E.)
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D. KNICKERBACKER BOYD
HARLAN S. MINER
D. ROBERT YARNALL

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F. C. DUNLAP, Chairman
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WM. POOL PARKER
H. A. STOCKLY, Sec'y of Comm.

CONSERVATION OF FUEL

GEORGE R. HENDERSON, Chairman
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H. F. SANVILLE
R. H. FERNALD
H. L. MOODY
E. B. CARTER
A. C. WOOD

SECRETARY TO THE SECRETARY

S. M. SNEDEKER

COMMITTEE ON PAPERS

LEWIS H. KENNEY, CHAIRMAN

DR. H. M. CHANCE

SPECIAL MEETING

At the Club House, Tuesday, April 2, 1918, 8.15 P.M.

The address of the evening will be made by **Dr. H. M. Chance,** Member, on

"A New Method for Separating Slate from Coal"

The method, which is an entirely new departure in the art of making separation of slate from coal, will be demonstrated by apparatus which will show how this is accomplished. The method and apparatus are not similar in any respects to any of the forms of concentrators, jigs or other appliances heretofore used in separating materials of different specific gravity, the principle underlying the operation of this new method being the utilization of differences in specific gravity of the materials to be separated by the use of a fluid medium of intermediate specific gravity; in other words, a fluid medium in which the lighter material will float and the heavier material will sink. The application of the method is not confined necessarily to the separation of slate from coal, but can be used in the concentration of metallic ores by separating the ore from the rock with which ores are usually associated.

MEETING FOR JUNIOR MEMBERS

Tuesday, April 9, 1918, Meeting at the Engineers' Club

The following paper will be presented:

" Standardization of Steel Mill Building Construction. " By R. B. Nicholson

JUNIOR PRIZE

All papers to be considered for the Junior Prize must be submitted on or before April 15, 1918, to the Chairman of the Committee on Papers.

PRELIMINARY ANNOUNCEMENT

Tuesday, May 21, 1918, 8.15 P.M., **at the Club-house.** Address to be made by retiring President, **Major John A. Vogleson.**

Tuesday, June 18, 1918, 8.15 P.M., **at the Club-house.** The Junior Prize paper will be presented by the author.

REGULAR MEETING

At Witherspoon Hall, Tuesday, April 16, 1918, 8.15 P.M.

The address of the evening will be made by **Morris Jastrow, Jr., Ph.D., LL.D.,** Librarian, University of Pennsylvania, and Professor of Semitic Languages, on

" The War and the Eastern Question "

The paper will be illustrated with lantern slides.

Members of Affiliated Societies are cordially invited to attend.

Members of the Club and Affiliated Societies are privileged to invite ladies.

The Eastern question is an ancient heritage. Professor Jastrow will show in his lecture the early age to which this troublesome problem can be traced back. There are several aspects of the Eastern question—one connected with the Balkan States, another connected with Asia Minor and the lands adjacent to it—Palestine, Mesopotamia, Egypt and Arabia—and, thirdly, the Far East. In this lecture Professor Jastrow will confine himself to the Near East and show the historical relations existing between the East and West from early days down to the present. The illustrations will show the changes in the map as we pass down the centuries and will also depict the character, the customs, the religious beliefs and the achievements of the various peoples forming the population of the Near East. The lecture will close with a survey of the special bearings of the Eastern question on the issues involved in the war.

DR. MORRIS JASTROW, JR.

DR. FREDERIC POOLE

SPECIAL MEETING

At Witherspoon Hall, Monday, April 29, 1918, 8.15 P.M.

The address of the evening will be made by **Dr. Frederic Poole,** on

"Social, Political and Industrial Revolution of China"

The paper will be illustrated with colored lantern slides and motion pictures.

Members of Affiliated Societies are cordially invited to attend.

Members of the Club and Affiliated Societies are privileged to invite ladies.

CALENDAR OF REGULAR MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

1918

DAY OF MONTH AND WEEK	NAME OF SOCIETY
First Monday	**American Society of Civil Engineers**
Second Monday	**American Institute of Electrical Engineers** April 8, May 13, June 10.
Third Monday	**Engineers' Club**
Fourth Monday	**Philadelphia Safety Council** April 22, May 27, June 24.
Fifth Monday	**Engineers' Club** April 29.
First Tuesday	**Engineers' Club (April)** April 2.
Second Tuesday	**Engineers' Club (Junior Meeting)** April 9.
Third Tuesday	**Engineers' Club** April 16, May 21, June 18.
Fourth Tuesday	**American Society of Mechanical Engineers** May 28, June 25.
First Wednesday	**Technology Club** April 3, May 1, June 5.
First Thursday	**Worcester Tech Club** April 4, May 2, June 6.
Second Thursday	**American Society of Heating and Ventilating Engineers** April 11, May 9, June 13.
Fourth Thursday	**Society of Automotive Engineers** April 25, May 23, June 27.
Third Friday	**Illuminating Engineering Society** April 19, May 17, June 21.

Engineers' Club Meetings at Witherspoon Hall will be as follows:

Tuesday, April 16, **Engineers' Club** Meetings.
Monday, April 29, " " "

Members of all Affiliated Societies are invited to these meetings.

SCHEDULE OF MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

APRIL, 1918

Tuesday,	**April 2, 1918**	Special Meeting Engineers' Club "A New Method for Separating Slate from Coal" **Dr. H. M. Chance**	**Engineers' Club**	8.15 P.M.
Wednesday,	**April 3, 1918**	Technology Club of Philadelphia "Fire Protection" **R. E. Page** Annual Meeting. Dinner at 6.30 P. M.	**Engineers' Club**	8.15 P.M.
Thursday,	**April 4, 1918**	Worcester Tech Club	**Engineers' Club**	8.15 P.M.
Monday,	**April 8, 1918**	American Institute of Electrical Engineers "Electrification of Railroads in Its Relation to Communication Lines" **H. S. Warren**	**Engineers' Club**	8.15 P.M.
Tuesday,	**April 9, 1918**	Junior Meeting "Standardization of Steel Mill Building Construction" **R. B. Nicholson**	**Engineers' Club**	8.15 P.M.
Thursday,	**April 11, 1918**	American Society of Heating and Ventilating Engineers "Vacuum Systems" **G. A. Eagan**	**Engineers' Club**	8.00 P.M.
Tuesday,	**April 16, 1918**	Regular Meeting Engineers' Club "The War and the Eastern Question" **Dr. Morris Jastrow, Jr.**	**Witherspoon Hall**	8.15 P.M.
Friday,	**April 19, 1918**	Illuminating Engineering Society "Progress in Illuminating Engineering During the Past Year" **F. E. Cady** **R. F. Pierce**	**Engineers' Club**	8.00 P.M.
(Date to be Announced)		American Society of Mechanical Engineers (Dinner and Entertainment of the National Society Council by the Philadelphia Section)		
Monday,	**April 22, 1918**	Philadelphia Safety Council "The Woman in Industry" (Dinner at 6.30 P.M.)	**Engineers' Club**	8.15 P.M.
Thursday,	**April 25, 1918**	Society of Automotive Engineers	**Engineers' Club**	8.15 P.M.
Monday,	**April 29, 1918**	Special Meeting Engineers' Club "Social, Political and Industrial Revolution of China" **Dr. Frederic Poole**	**Witherspoon Hall**	8.15 P.M.

SECRETARY'S NOTICES

A BUSINESS MEETING of the Club will be held Tuesday evening, April 16, 1918, at 8:15 o'clock, at Witherspoon Hall.

In accordance with the By-Laws, Article V, Section 5, additional nominations for officers may be presented, in writing, at this meeting.

H. A. STOCKLY, *Secretary.*

ABSTRACT OF MINUTES OF THE BUSINESS MEETING OF THE CLUB

HELD MONDAY EVENING, MARCH 18, 1918

The meeting was called to order at 8:15 P.M. by Mr. George R. Henderson. About 500 members and guests were in attendance.

The minutes of the Special Meetings of January 29 and February 6, 1918, and the Business Meeting of February 19, 1918, as printed in the JOURNAL, were approved.

It was announced that the Board of Directors, at its last meeting, elected the following to membership: Active, 10; Junior, 1.

The report of the Committee on Nominations was presented as follows:

Mr. President and Members of
The Engineers' Club of Philadelphia.

GENTLEMEN:

Your Committee appointed to name candidates for offices to be filled at the next annual meeting have performed their duty, and are pleased to make the following nominations:

For President (to serve one year)
J. FRANKLIN STEVENS
For Vice-President (to serve three years)
JOSEPH C. WAGNER
For Treasurer (to serve one year)
LEWIS H. KENNEY
For Directors-at-large (each to serve one year)
S. M. SWAAB
PAUL SPENCER
H. P. GANT
W. H. CONNELL
WALTER E. LONG

We also enclose herewith the written acceptance of each of the above-named nominees.

Respectfully submitted,
(Signed) CARL HERING
THOS. C. MCBRIDE
FRED C. DUNLAP
WM. J. SERRILL
W. P. TAYLOR
STAUNTON B. PECK
W. P. DALLETT, *Chairman*

Major W. A. Garrett, assistant general manager, Remington Arms Company, presented a short address on "Some of My Observations in France," which was followed by an address by Mr. John S. Rossell, president, Security Trust and Safe Deposit Company, Wilmington, Del., entitled "The Measure of Our Sacrifice in the Present World Conflict."

Thru the courtesy of Rear Admiral Benjamin Tappan, U. S. N., Retired, Commandant of the Philadelphia Navy Yard, the Navy Yard Band rendered selections at the meeting.

A unanimous vote of thanks was extended to the speakers and to the band.

The meeting was recessed at 10 P.M., to reconvene on Tuesday evening, March 19, at 8:15 o'clock, at the Club-house.

ABSTRACT OF MINUTES OF THE RECONVENED BUSINESS MEETING OF THE CLUB

HELD MARCH 19, 1918

The meeting of March 18 was reconvened at 8:15 P.M., at the Club-house.

The report of the tellers on the amendments to the By-Laws was presented, as follows·

Mr. President and Members of
The Engineers' Club of Philadelphia.

GENTLEMEN:

Your Tellers have counted the votes cast on the amendment to Article I, Section 2, and Article VII, Section 2, of the By-Laws, and declare that 336 legal ballots were cast, as follows:

For Article I, Section 2, 276—Against Article I, Section 2, 60.
For Article VII, Section 2, 274—Against Article VII, Section 2, 62.

Respectfully submitted,
(Signed) GEO. E. CROFOOT
JOHN P. MUDD
CHAS. F. PUFF, JR.
H. GOODWIN, JR.

The amendments were therefore declared adopted.

The meeting adjourned at 8:30 P.M.

REGULAR MEETING OF THE BOARD OF DIRECTORS

HELD MARCH 12, 1918

The meeting was called to order at 7:30 P.M., with Vice-President Yarnall, Directors Fernald, Gant, Kenney, Moody, Forstall, Bullens, R. M. Barr, Douglas, Past Presidents Swaab and Carter, Treasurer Stevens, and Secretary in attendance. President Vogleson, Vice-Presidents Andrews and Eglin, Directors G. W. Barr, Henderson, J. C.

Wagner, S. T. Wagner, Ehle, and Past President Ledoux were excused. Director Hayward was absent.

The minutes of the Regular Meetings of January 8 and February 12 and the Special Meeting of February 5, as issued to the members of the Board, were approved.

REPORT OF THE PRESIDENT

Mr. Yarnall reported that Mr. W. P. Dallett has accepted the chairmanship of the Committee on Life Membership, and Mr. Robert M. Barr the chairmanship of the Committee on Increase of Membership.

A letter was read from President Vogleson, stating that he would be pleased to comply with the desire of the Board that he remain as president for the remainder of his term.

REPORT OF THE SECRETARY

A letter having been received from the Secretary of the Board of Trustees, Pennsylvania State College, requesting the Club to appoint three delegates to the annual meeting to be held in the Old Chapel, State College, 2 P.M., April 23, 1918, for the purpose of electing twelve members of the Board of Trustees, the President was authorized to appoint them.

A letter was read from Mr. M. G. Bittel, chairman of the Club and Public Relations Committee of the Junior Section, asking for representation on the Board of Directors, and the Board ruled as follows:

"For the presentation of any matter they may wish to bring to the attention of the management the Juniors, upon their request, be permitted to have a representative in attendance during such time as Junior matters are under discussion at the meetings of the Board. It was the further desire of the Board that the Juniors be encouraged to work out their problems with the existing committees of the Club, as outlined in Mr. Kenney's letter of March 1, 1918."

The request for reinstatement made by Mr. Edward S. Clinch, Jr., whose resignation as an active member in good standing was accepted in November, 1917, was granted.

The resignation of Mr. Edward M. Miller, Active member, was presented and accepted.

Subsequent to the last meeting of the Board, the following have been transferred to Life Membership:

J. Lawrence Hagy
Stewart A. Jellett
R. C. Morgan

REPORT OF THE TREASURER

The financial report of the Treasurer as of February 28, 1918, and the quarterly report of the auditors as of January 31, 1918, were presented and accepted.

Thru Mr. Stevens, Mr. Dallett, chairman of the Committee on Life Membership, requested the Board to remit the dues for the year 1918–19 for such members as shall have paid the Life Membership fee during the month of April, 1918, and the Board granted the request.

REPORT OF THE COMMITTEE ON HOUSE

The Committee recommended that the list of clubs and societies with which the Club exchanges privileges be divided between the societies with which the Club exchanges technical and library privileges only and those with which full Club-house privileges are exchanged.

The Committee was authorized to formulate rules for exchange privileges, and to write the various clubs and societies, explaining such rules, report to be made to the next regular meeting of the Board.

The Board further authorized that the issuing of 1918–19 membership cards be deferred for thirty days, in order to give the Committee time in which to settle the question of exchange privileges.

REPORT OF THE COMMITTEE ON MEMBERSHIP

At the recommendation of the Committee, the following were elected:

To *Active* Membership:

Vernon F. Alley
Clarence E. Fairbanks
Milton W. Franklin
James C. Goddard
Harold S. Hayden
Leif E. Norbom
Samuel E. Ourbacker
Wm. J. L. Roop
Harry J. Stockum
Floyd W. Woodcock

To *Junior* Membership:

L. Cheyney Smith

REPORT OF THE COMMITTEE ON PUBLICATION

The Committee presented a report, which was accepted by the Board, showing an unexpended balance in its appropriation of $68.68.

REPORT OF THE COMMITTEE ON PAPERS

The Board accepted the report of the Committee, which was as follows:

Arrangements have been made for a meeting of the Club at Drexel Institute, March 18. The date for the regular meeting, in accordance with our By-Laws, would be March 19, but verbal authority of the senior Vice-President was obtained to make the change in date, in accordance with the By-Laws, Article II, Section 2. This meeting will be a Business Meeting, in view of the fact that there will be committee reports to be presented.

The Committee had made tentative arrangements for a paper on "The Application of Science to the European War," but was unable to obtain the prospective speaker. Arrangements were therefore made for an address on "The Measure of Our Sacrifice in the Present World Conflict," by Mr. John S. Rossell, president of the Security Trust and Safe Deposit Company, Wilmington, Del., and chairman for New Castle County, Third Federal Reserve District, Liberty Loan Committee. At his suggestion, we have arranged thru the Liberty Loan Committee of Philadelphia for Major W. A. Garrett, assistant general manager of the Remington Arms Company, to present a short talk on "Some of My Observations in

(Continued on Page 201)

COMMITTEE ON MEMBERSHIP

D. ROBERT YARNALL, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before April 8 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

ARCHIBALD LEVY ALTEMUS

3203 West Penn Street, Philadelphia, Pa.
Sales Engineer, Trussed Concrete Steel Company, Youngstown, Ohio.
Proposed by A. E. Yarnall, James W. Pearce, and Harry W. Payne.

JOHN FOLSZ

21 Fern Avenue, Collingswood, N. J.
Chief Draftsman, Otis Elevator Company (Philadelphia Zone).
Proposed by W. M. Manning, E. W. Deakin, and F. K. Worley.

FREDERICK B. SANSOM

125 West School Lane, Germantown, Philadelphia, Pa.
Mechanical Engineer.
Proposed by Emmett B. Carter and John P. Mudd.

JOHN EDWARD SNYDER

1847 North Sixth Street, Philadelphia, Pa.
Engineer and Contractor.
Proposed by Charles W. Russ and Edwin Smith.

RICHARD H. TRIMBLE

Exton, Pa.
Manager, Machinery Department, Pennsylvania Steel Export Company.
Proposed by H. A. Jenscnius, J. Franklin Stevens, and Thomas C. McBride.

EDWARD HENRY WARNER

Wyneva Apartments, Section "A," Wayne and Wyoming Avenues, Germantown, Philadelphia, Pa.
Production Engineer, Midvale Steel and Ordnance Company, Philadelphia, Pa.
Proposed by C. E. Barba and John P. Mudd.

SECRETARY'S NOTICES

(*Continued from Page 200*)

France." The Commandant of the Philadelphia Navy Yard has kindly detailed the Navy Yard Band tô provide music for this meeting.

The character of the meeting is radically different from any which the Committee has previously arranged, but it was thought desirable for the Club to go on record as having rendered a public service to the Government at this time.

The schedule of papers for the remainder of the season was presented and approved.

REPORTS OF SPECIAL COMMITTEES

Committee on National Service

It was announced that, with the approval of Mr. Yarnall, the Club mailing list had been made available to the Citizens' Committee of the Liberty Loan Association in Philadelphia.

At the request of this committee for suggestions from the Board, the Committee Chairman was instructed to use his own discretion with the Liberty Loan Committee and with the Food Commissioner, with a view to offering the services of the Club or his Committee, as he sees fit.

Committee on Conservation of Fuel

The Committee presented a request from the Robert W. Kennedy Company to reprint and issue the article on "Coal Thrift" prepared by the Committee.

The Board granted permission to the Robert W. Kennedy Company and similar concerns to reprint the article on "Coal Thrift," as prepared by the Committee, on condition that such concerns submit proof to the Club before the final printing, in order that it may be seen that the arrangement of type and setting shall be satisfactory.

NEW BUSINESS

It was suggested by Mr. Moody that the Board consider the question of whether or not it will maintain the sale of liquor during war times, as a matter of food conservation and as a war measure, and the matter was referred to the Committee on House, to report at the next meeting of the Board.

The meeting adjourned at 9:55 P.M.

H. A. STOCKLY,
Secretary.

REMARKS ON THE OCCASION OF OPENING THE NEW DINING-ROOM, MARCH, 1918

EDWARD J. CATTELL

MR. PRESIDENT and my friends of the Engineers' Club:

Every time a friend tries to introduce me I brace myself for a shock, because every night I meet friends I never met before. I suppose I ought to keep still, but I can't. My father used to say when I was a boy that my tongue was hung at the middle and wagged at both ends. At the end of a banquet I am very apt to be in the condition of the bright little boy I took dinner with in Yorkshire. When he got thru he said to his nurse, "Pick I up; carry I out, but don't bend I." Bendability is the keynote of sociability. I must congratulate you, my friends, on the wonderful success of this dining-room. You cannot run the machine without firing up.

While in St. Louis last year, making a flying trip from one State to another, the papers printed much about the slow men of Philadelphia. One night after speaking as I sat down in the dining-room of the Planters' Hotel to get some supper, a fellow with the old-fashioned idea of Philadelphia came over to me and said, "Can I get you anything?" I said, "Yes; I came from Philadelphia, where we go to bed very early, but I am accustomed to eat something very simple and light before I go to bed." He said, "How would you like a little toast with some hot tea?" It did not strike me, so I said, "Try again." He said, "You might possibly stand some scrambled eggs." I said, "That does not strike me. I will take what I eat every night when I am at home. Bring me some lobster a la Newburg, a cup of coffee and a piece of apple pie." The waiter brought it in and I would have died rather than fall down, so I ate it. I saw four waiters in line watching me. The next morning I heard one of them say to the captain, "By Jove, the old man is still alive!"

There has never been a more carefully planned piece of legislation—one more thoroly investigated and thought out—than our present currency and banking system. I was at a bankers' dinner not long ago at which representatives from nearly every great financial interest were present, and it was the unanimous opinion that the enactment of that legislation was almost providential in its character. It released and put at the service of the commercial world over fifty thousand million dollars of wealth that we could not touch before, and made possible the rapid financing of this world war. That legislation is noted for one feature, a feature which everybody should bear in mind. Here is a nation of 110 million people covering 3,600,000 square miles of territory, with an immense number of cities, a great diversity of interests, and yet our legislative authorities, having the general good in mind, placed two of the twelve great money centers of America within ninety miles of each other. Philadelphia was discovered by the highly trained financial experts to have so much original wealth, such tremendous capital investments all over this country, was found to have so many men with ideas and ability to do things in a way that spelled success, that when they came to divide the nation's financial power—the greatest financial power of the world—they put two banks within ninety miles of each other—the great federal reserve banks, one in Philadelphia and one in New York. The nearest Southern bank is located at Richmond, Va., and the nearest Western bank at Cleveland, Ohio.

That was a remarkable action, and it was justified. There is no large city in the world with a greater wealth per capita than Philadelphia. Nobody can get exact figures on the city wealth, but I think we will go over $6000 per capita, which is more than three times the general per capita wealth of the nation. Our State possesses certain characteristics. Instead of the farmers going out of the State to spend money, after harvests are gathered in, a great number stay at home, making cigars and underwear. We have been a thrifty people for 225 years, and, with the wealth born of that thrift, have stood back of every engineering development in America.

This is an engineering war, gentlemen. Philadelphia is the mother city of the great idea for which this war is being fought—liberty—and it seems to me there could be nothing more appropriate, nothing more valuable to the country at large, than that you should have this engineer home center where men can meet men of kindred facts and kindred talents, where they can foregather with men from other cities, consult with them; where they will find opportunity to impress others with that idea of stability, of reality, of actuality, which is the dominant note of Philadelphia.

You will do everybody good that you bring into this splendid Philadelphia Club; I do not care what city you may have been born in; when you come to Philadelphia as an adopted home you catch a little of that poise which makes you a real citizen of a real republic. We are not jealous of any other city. The average Philadelphian can hold his own, there is no difficulty about that. Do not become possessed with the idea that we are second to anybody or inferior to anybody. If a thing is worth doing, Philadelphia does it; if not, we let it alone and do not talk about it. We conserve energy.

I am an optimist, first, because I am a Philadelphian;

second, because I know that, given certain conditions in the body politic, and certain qualities or opportunities in or for the individual, there is only one result—success. I was asked a conundrum one time: "How far can a dog run into the woods?" I replied, "As far as he wants to." The answer was, "No; after he has gotten half way in, he is running out, isn't he?" When you get beyond midnight you do not get deeper into the *night* but nearer to the new day. That is the American attitude toward any dark night—any crisis. When I hear these terrible prophecies about America, how they stir my anger! You will see a notice in the papers that Congress appropriated forty-two million dollars a day—ruining the country; but nobody says that during that time America created one hundred million dollars new wealth out of which to pay that forty-two million—not a word.

Now, my friends, here is another fact: When I was young the wealth of America was seven thousand million dollars. A conservative estimate to-day puts it at two hundred and thirty-seven thousand million dollars. Two hundred and thirty thousand million dollars have come into existence in this country in the span of my life. Do you wonder that I am an optimist? Our immense wealth is the greatest ever concentrated in any country in the world. We are one hundred and forty-two years old; yet what we have in the way of national wealth is only the production of five years—less than that. This means that in any year about 85 per cent. of what we produce we consume, either thru the waste of social and peaceful life or thru the waste of warfare and warlike life. Economically, there is no difference between blowing up $100,000 of powder in a pyrotechnic exhibition or in a battle, not the least. I venture to prophesy at the end of this war—and I believe it will come within eighteen months—that we will not show an impairment of over 10 per cent. in accumulative wealth; that the whole cost of this war will be paid, less that 10 per cent. (which will be about $30,000,000) out of the savings which we make, without stopping business. In the Civil War period we cut our expenditures in Philadelphia three-fifths without feeling it and without rigid economies. My estimate is that we are spending about five to six million dollars a day in Philadelphia now. This one city, with less than 2 per cent. of the country's population, can stand 5 per cent. of the expense of the war and not feel it.

You must keep your faith in America; but you will have to start out with the will to believe and not fall over trifles. I stopped one of our general officers the other night and said, "I hear you are punishing men for too trivial offences at the Navy Yard." He said, "What is it?" I said, "You sent a man out the other day to get 'Recruits' and he brought in 'Piedmonts' and you gave him six days." Many penalties that we fix upon ourselves are just as foolish; we are always looking for trouble. I had a friend who was annoyed by the barking of a dog. He opened the window and held the dog out until it froze to death. He killed the dog, but we buried the man with pneumonia a week later. Another was bothered with a fly. The fly lit on a valuable watch. He struck at it and killed it, but he destroyed a $500 watch at the same time. He did not wait for the fly to get off the watch. It is very much the same with amateurs experimenting with our machinery of war and commerce in the final result. At the close of this war it is going to be a question of the survival of the fittest, and if we destroy by breaking up the whole transportation and producing system of the nation, then when peace comes we will be fifteen years getting back to the old position of wealth production and other nations will capture foreign trade and will have skimmed all the cream off before we can get at it.

Do not forget the fact that America has become great thru her ability to create new buying power and not economies. You will see abroad into how many pieces they split a penny. We do not do that. We are like that old Spartan king who turned to the wonderful musician when he got thru and said, "I cannot fiddle, but I can make a small town a great city." We have the talent to take an acre of ground that twenty years ago was producing $15.00 an acre and make it produce season after season $950.00 an acre instead of $15.00. We have the talent to go into sections of this country where, forty years ago, we had sections marked "arid" in every geography in the world and by the splendid scientific engineering skill of our country make it possible to raise three crops a year. We have not only seven hundred and fifty million acres in total ground area in America not in use, but a thousand million acres on which we can increase our production 800 per cent. The next time you take a ride to Boston, just keep tab on the unused land which rolls by. Now it is the power which is at our command to get out of that land which was before called arid this marvelous result that is to be the help of America.

It is thru the skill of your wonderful engineering profession that we are to solve the great problem of transportation—that Europe is to be rebult, and many of those old roads in Europe, which originally followed historic lines and doubled the distance between two points will be rebuilt on the air-line plan. They are going to be built in the new way that will lessen transport cost over those roads to a sufficient amount to pay for the capital cost of improvement. Do you realize that in this country we have eighteen hundred thousand miles of road over which it costs twenty-five cents a ton for moving products where it ought to be only ten cents? Do you realize that there are points where miles of slack can be taken out, that the average haul to the first point of shipment by rail is over nine miles from the point of production, and a difference of twenty cents a mile added to the cost of moving makes the cost so high that many products are not moved at all?

I envy you, my friends, in your mighty day of opportunity with your God-inspired skill. With a world torn with blood and tears and pain coming back to its senses and once more showing the God creative and constructive, to be able to lead, to be able to guide, to bring order out of chaos, *that* is something, because that which we do reacts on the doer, and in this splendid age it seems to me that in America there are only two things for an American: He has either to live to serve or die to save. No matter whether you are at the front, going over the top, or at home working to back up the man who is going over the top, in each instance you perform an act of heroism in bringing mankind closer to the living God, enabling him to get a new grip on the splendor of life and the dignity of living. This nation is dividing into hogs and heroes, and the hogs have a right to live and enjoy their natural environment. I do not say that the hog has not a right to live, but he must not complain if people treat him and his hog-like environment with disgust. It is not the world that owes me a living, I owe the world a life. Out of this contest is to come a higher type of manhood, a greater joy in living. Let us get rid of all this pessimism; it is poison down to the roots. When I read these pessimistic articles I just wonder if the writers are not working in the wrong direction. You can always, if you want to, get proof for a theory; if you are firm enough in the theory you will find the proof; that is the difficulty. Too few people go at the problem with an open mind.

If I had any story to bring to you to-night, it is this: In the first place, life gets better the longer you live, so you need not hurry. In the second place, nobody can be happy in America unless he is playing ball, and that means hitting the ball and not the umpire. There is an awful difference. We have ninety-nine critics for one creator. Get into the class of patting on the back and believing in ourselves and believing in others.

I spoke about the economic conditions underlying this war. I have a right to speak with some authority. I was trained with Jay Cooke and George C. Thomas—the men who built the Northern Pacific and reorganized the Reading Railway, and a number of other great properties. I have been in touch with banking interests for over forty-five years. We are working along the cleanest, sanest lines of any nation that ever entered and passed thru a great war. We have practically rendered fluid every dollar of our two hundred and thirty-seven thousand million of national wealth, thru the addition of our loan banks and our present currency, and we can fight this war for twenty-five years and win it!

I have visited twelve of the big cantonments and gatherings of troops. I have spoken to groups as large as 7000 in number of our soldiers and sailors. During a total of eighteen to twenty years' residence abroad I have come in contact with the armies of the nations opposed to us. I want to go on record—and the facts will prove whether I am wrong or right—that our boys, given equal equipment, can beat three to one of the soldiers abroad. Within a week I put that statement up to an army officer in the United States Army with twenty-five years' experience, a man who has been in Europe watching the troops in this war. I said, "Am I making a foolish statement?" He said, "No; I would make it four to one and risk my reputation."

We go into this war, which is an engineering war, after three years' experience which has proved many of the old theories to be absolutely false. A member of a great committee that investigated weapons before this war told me that experts were unanimous in opinion that the bayonet should be discarded as a useless weapon in war. The records of this war show more men have been killed with the bayonet than with the bullet. Germany has been forty years getting ready. There have been tremendous developments in those forty years, and these three years of war have made wonderful developments. We are going into it with machine power, man power and heart power, with the knowledge of the mistakes that others have made. We should go into this war with malice toward none, with charity for all. I do not believe in creating hate, but when a man asks me whether my mother was a good woman I do not argue with him; I knock him down. There is no middle ground. We are coming thru this war victors, and we are coming thru it having found our soul as a nation—going back to many of the old habits and traditions that made our land great, because our forefathers practiced and believed the clean things—clean thinking and clean living without giving thought of self—that will make a bigger and stronger nation. Material reasons make me optimistic, but beyond and above all are the spiritual feelings and aspects. I would like to leave with you a picture that I have left in a great many places over this country. It has helped me and it may help you. Last year during the Liberty Loan campaign I went down to see that the bell in the State House tolled on time. There I met a picture that I would not give up for a great deal. I heard a dispute between a police officer and a sailor. The officer turned to me and said, "This man is insisting on getting into Independence Hall to see the bell. We don't have a light there at night and he won't take no for an answer." I turned to this splendid young fellow and asked, "Can't you come to-morrow?" He said, "That is impossible. We sail at 5:30 in the morning on the converted German cruiser. We are going to the fighting zone. I only reached Philadelphia from Wisconsin at 6 P.M. My mother was a Philadelphian. I have never been here before. The Liberty Bell and the Bible were the foundations of her life. My father died when I was young. Last April God took my mother from me. I feel I will be nearer to her when I am fighting. I would love to see the bell, if I could." I said, "My boy, you shall see it, rules or no rules." I heard the watchman coming down the tower from his customary station and I said, "Will you open the door? I am speaking in the name of the Mayor, and I know that he would want this sailor to see that bell." He said, "All right, if you take the responsibility, Mr. Cattell." I said, "I won't ask you to put a light." The young man and I went in; he put his hand on the bell and then I stepped into the shadow, to the west, thinking I would remove the curtain and give him a little more light. Evidently, when I disappeared into the

(Continued on Page 211)

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, CHAIRMAN

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF MARCH 25, 1918

NAME	RANK	CORPS	LOCATION
Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, H. Butler	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, via New York
Allen, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Anders, D. W.	Major	Company D, 502nd Engineers	American Expeditionary Forces, France
Andrews, J. H. M.	Major	Ordnance R. C.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
Asplundth, E. T	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Atterbury, W. W.	Brigadier-General	Director-General of Railways	France
Baker, W. D.	2nd Lieutenant	Aviation Corps	France
Banister, E. S.	Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Barker, E. W., Jr.		Truck 4–304 Ammunition Train	Camp Meade, Admiral, Md.
Bassett, F. H., Jr.		Officers' Training School	Camp Meade, Md.
Bear, H. K.	Lieutenant	Gas Defense Service	Camp Greenleaf, Ft. Oglethorpe, Ga.
Bell, Frank F.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
Bescherer, P.	2nd Lieutenant	319th Heavy Artillery	Camp Gordon, Ga.
Betus, A. J.		111th Infantry	Camp Hancock, Augusta, Ga.
Biester, W. H., Jr.	Corporal	"Co. E," 103rd Engineers	Camp Hancock, Augusta, Ga.
Bishop, A. B.		U. S. Radio School	College Park, Md.
Booz, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	Amer. Exped. Forces, via New York
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. F.	Lieutenant	U. S. Naval Reserve Force	Submarine Base, New London, Conn.
Boyd, G.	1st Sergeant	Overseas Repair Section No. 1	Gas Defense Service, Medical Corps
Bradford, J. S.	Major	103rd Engineers	Camp Hancock, Augusta, Ga.
Bradt, Morris	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Bransome, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
Bream, C. C.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Breen, J. W.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Brewer, P. C., Jr.	2nd Lieutenant	307th Engineers	Camp Gordon, Atlanta, Ga.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Broadhead, Alex		19th Reserve Engineers	American Expeditionary Forces, via New York
Broderick, D. F.	Major	Ordnance Officers' Reserve Corps	Rock Island Arsenal, Rockland, Ill.
Brown, J. A.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier-General W. W. Atterbury
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, via New York
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. F.	Lieutenant	462nd Co. (Motorcycles), E. M. S. S.	Fort Myer, Va.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.		Carriage Division, F. A. Section	Washington, D. C.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Chance, T. M.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Childs, H. P.		7th Infantry	
Cleeland, R.	Cadet Engineer	S. S. Neuse	Care U. S. Shipping Board
Colgan, R. J	Captain	11th Regiment Engineers	Care of Adjutant-Gen'l, Washington, D. C,
Craig, Coulter	Captain	Ordnance Officers' Reserve Corps Supply Division	Office, Chief of Ordnance Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	Camp Hancock, Augusta, Ga.
Crowther, E. C.	Corporal	Jefferson Hospital Unit	
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Cutler, James B.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Day, R. F.		Signal Corps, Aviation Section	Ellington Flying Field, Houston, Texas
Derby, C. F.	Captain	Ordnance Officers' Reserve Corps	Camp Lee. Petersburg, Va.

Dill, C. M.		First Battery, Reserve Officers' Training Camp	Camp Lee, Petersburg, Va.
Donnelly, J. B.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Doyle, T. H.	2nd Lieutenant	U. S. Quartermaster's Corps	Phila. Expeditionary Depot, 906 S. Broad St.
Dunlap, V. R.	Lieutenant (Jr.)	Ass't Civil Engineer, U. S. N.	Naval Air Station, Pensacola, Fla.
Dunn, M. L.	Ensign	"U. S. S. Connecticut"	Care Postmaster, N. Y.
Dyson, C. W.	Rear Admiral	Bureau of Steam Engineering, U. S. N.	Washington, D. C.
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.
Elcock, Chas.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Farr, Roy S.	2nd Lieutenant	301st Engineers' Train	Camp Devens, Ayer, Mass.
Faust, W. D.		103rd Engineers	Camp Hancock, Augusta, Ga.
Fenton, Powell		Aviation Corps	France
Ferree, D. S.	Engineer Officer	Aviation Section, Signal Corps	M. I. T. School of Military Aeronautics, Cambridge, Mass.
Fish, W. N.	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Maryland
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	American Expeditionary Forces, France
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gauthier, Jordan	2nd Lieutenant	56th Engineers	Washington, D. C.
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Getz, Ralph F.	2nd Lieutenant	32nd Engineers	Camp Grant, Ill.
Gilbert, W. T.		21st Railway Engineers	American Expeditionary Forces, via New York
Gillan, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Goodwin, H., Jr.	Lieutenant	U. S. Naval Reserve Force	
Gracey, A. L.	Private	Advance Ordnance Depot No. 4	American Expeditionary Forces, via New York
Gravell, W. H.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Gray, B. D.	Major	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
Gribbel, W. G.	Captain	30th Engineers	American Expeditionary Forces, via New York
Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C.
Grossman, P. R.	Private	447th Depot Detachment Engineers	Camp Devens, Ayer, Mass.
Gwilliam, Mark R. M	1st Lieutenant	21st U. S. Infantry	San Diego, Calif.
Hall, W. A.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	105th Engineers	Camp Sevier, Greenville, S. C.
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hathaway, H. K.	Colonel	Ordnance N. A.	Washington, D. C.
Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
Heger, J.	Lieutenant	Engineers' Depot	Washington, D. C.
Henry, J. C.		Headquarters Dep't 19th Reserve Engineers	Amer. Exp. Forces, via New York
Hrtherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Infantry	Charlotte, Ga.
Hollenback, B. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.	1st Lieutenant	Dental Corps, 28th Division	Camp Hancock, Augusta, Ga.
Houwen, W. P.	C. M. A. A.	United States Navy Air Station	Cape May, N. J.
Hulmr, Norman	1st Lieutenant	458th Truck Co.	Fort Myer, Va.
Hyland, G. N.	Cadet	U. S. A. Flying School	Park Field, Memphis, Tenn.
Jones, Jonathan	Captain	23rd Regiment Engineers	American Expeditionary Forces, via New York
Kennedy, J. H.		Aviation Section, Signal Corps	American Expeditionary Forces, via New York
Kern, F. X.	Lieutenant	23rd Regiment Engineers	American Expeditionary Forces, via New York
Klein, A. C.	Lieutenant	Production Section, Gun Division	Office, Chief of Ordnance, Washington, D. C.
Kneass, E.	Ensign	U. S. Naval Academy	Annapolis, Md.
Knight, C. C., Jr.	Lieutenant	81st Division, Field Artillery	Camp Jackson, S. C.
Koelle, W. F. B.	Sergeant	Signal Corps	Washington, D. C
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	Amer. Exp. Forces, via New York
Lawrence, G. E.	Lieutenant J. G.	U. S. Naval Res. Force	U. S. S. "Nokomis," European Waters, care Postmaster, N. Y.
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Levin, J.		2nd Officers' Training Camp	Fortress Monroe, Va.
Lynch, N. L.		Engineer Officers' Reserve Corps	Washington Barracks, Washington, D. C.
MacGarrigle, G. L.	Private	Company "B," 103rd Engineers	Camp Hancock, Augusta, Ga.
Magee, J. W.	2nd Lieutenant	504th Engineers' Corps	Washington Barracks, D. C.
Mallon, G. J.	Lieutenant (Jr.)	U. S. Naval Reserve Force	U. S. S. "Mt. Vernon," care of Postmaster, N. Y.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Mardaga, L.	Ensign	U. S. Naval Reserve Force	Asst. Naval Inspector of Ordnance, Alloy Steel Forging Plant, Carnegie, Pa.
Martin, T. S., 3rd	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Mayburry, W. G., Jr.	Lieutenant	334th Field Artillery, National Army	Camp Pike, Ark.
McCausland, J. R	Master Engineer	446th Engineers, Depot Detachment	American Expeditionary Forces, France

McClintock, J. L.		U. S. Navy Radio Service	Parkway Bldg. *pro tem.*
McCord, J. B.	Lieutenant-Colonel	Ordnance N. A.	American Expeditionary Forces, France
McCormick, J. C.	1st Lieutenant	Engineer Officers' Reserve Corps	Amer. Exp. Forces, via New York
McCoy, J. F.	Cadet	Aviation Section, Signal Corps	Park Field, Memphis, Tenn.
McGarrigle, J. J.		2nd Officers' Training Camp	Fortress Monroe, Va.
McMillan, H. L.	Major	303rd Engineers	Camp Dix, Wrightstown, N. J.
Millar, E. A., Jr.	1st Lieutenant	Ordnance Officers' Reserve	Camp Hancock, Augusta, Ga.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Moon, T. E.	Corporal	119th Ordnance Depot Co.	Camp Hancock, Augusta, Ga.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Myers, W. C.	Captain	Ordnance Officers' Reserve	Washington, D. C.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	Captain	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixon-Miller, M.	Captain	Company "B," 501st Engineers	Camp Merritt, N. J.
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
Oakes, J. C.	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Orr, M. W.		First Battery, Officers' Training School	Camp Meade, Md.
Otwell, Curtis W.	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Perry, Edward	Sergeant	Motor Truck Company No. 329	Camp Lee, Petersburg, Va.
Peterman, J. M.	Private		Camp Meade, Admiral, Md.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Prichett, P. B.		103rd Trench Mortar Battery	Camp Hancock, Augusta, Ga.
Prince, H. W.		Squadron 80	Camp Eimerman, Fort Worth, Texas
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	79th Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	19th Reserve Engineers	American Expeditionary Forces, via New York
Reed, Thomas	Captain	Ordnance Officers' Reserve Corp	Inspector of Ordnance. Walter Scott & Company, Plainfield, N. J.
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Reninger, H. A.	Major & Adjutant, A.G. Dept.	53rd Depot Brigade	Camp Hancock, Augusta, Ga.
Ridge, R. S.	Sergeant	23rd Engineers	Camp Meade, Admiral, Md.
Ridgway, J. J.	1st Lieutenant	Co. "F," 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.	Private	201st Aero Squadron	12 W. 95th St., New York City
Roop, J. C.	Captain	17th Engineers	France
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	Washington, D. C.
Schaum, O. W.	Aeronautical Mechanical Engineer	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
Schmidt, A. H.		Company "C," 315th Infantry	Camp Meade, Admiral, Md.
Schoch, J. B.	Lieutenant	109th U. S. Infantry	Camp Hancock, Augusta, Ga.
Scull, A. H.	Lieutenant	Railroad Transportation Corps	American Expeditionary Forces, via New York
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defense Service, Med. Dept., U. S. A.	Washington, D. C.
Sheahan, J. C.	2nd Lieutenant	Co. 11, Section B, Bldg. 6	Camp Jos. E. Johnston, Jacksonville, Fla.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Smith, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	Overseas Service
Spillan, J. J. D.	Sergeant	Hq. 53, Brig. F. A.	Camp Hancock, Augusta, Ga.
St. John Everett	1st Lieutenant	Coast Artillery Reserve Corps	Fort duPont, Delaware
Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	1st Lieutenant	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
Thacher, C. H.	2nd Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
Thomas, R. S.	Lieutenant Colonel	312th Engineers	Camp Pike, Little Rock, Ark.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Corporal	Co. "B," 103rd Engineers	Camp Hancock, Augusta, Ga.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Maine"
Truhan, L. J.		Reserve Officers' Barracks "B," Room No. 373	Naval Academy, Annapolis, Md.
Uhler, W. D.	Major	Quartermaster Corps, N. A.	Washington, D. C.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal
Vaughan, D. L.	1st Lieutenant	Officers' Reserve Corps	Camp Joseph E. Johnston, Jacksonville, Fla.

Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Coast Artillery	Fort Greble, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces via New York
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	Engineer Officers' Reserve Corps	France
Wentz, E. M.	Asst. Paymaster	Receiving Ship	Brooklyn Navy Yard
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	Camp Hancock, Augusta, Ga.
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	C. A. C. School D	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Alex. Remount Depot, Macon, Ga.
Zeckwer, J. A.	Ensign	U. S. Naval Reserve Force	Boarding Officer, Port of Philadelphia
Zinn, George A.	Colonel	District Engineers' Office, Custom House	Portland, Oregon

PORTS AND TERMINAL FACILITIES

(Continued from Page 175)

great inland back of the city are the steel mills, the cement mills, the oil fields and coal fields, all pouring out their rich products into this city. Because of this the demands upon such a utility must necessarily be great and constantly grow.

What is being accomplished at the water front? The city is building substantial piers, the newer ones being of the two-deck type, and they are equipped with modern machinery for handling cargoes. There is no necessity for lighterage or lighterage charges. There is that great advantage over many ports, for cargoes can be loaded directly from rail to ship. As Doctor MacElwee said, a great expense comes thru insufficient facilities for handling the cargo at the port. We have a splendid fresh-water channel, and with our facilities for bringing the largest ocean freighters up the river directly to the piers we should attract the products of the country to the river front and handle them promptly and efficiently.

Now that public attention is called to the great congestion in New York City; that the barriers which have in a measure throttled the business coming to Philadelphia are being removed; that our railroads are being operated by the United States Government, with the ships controlled by the same authority—the economic advantages of the port of Philadelphia *must* be realized. No longer will it be necessary for merchants to send ships and cargoes to New York simply because they have been in the habit of sending them there. The Government of the United States must ship thru the most economic channel, and that economic channel they will find, for a large percentage of these cargoes, in ports other than New York.

COLOR IN ILLUMINATION

(Continued from Page 191)

For example, a living-room may be worked out in sedative gray with first installation of diffused lighting in recuperative rose, and second installation in recuperative orange, stimulant green and mauve. Once the key of this new color classification has been mastered, endless hygienic and esthetic combinations can be worked out.

It is quite possible for a lighting system to possess color-hygiene without possessing any esthetic value, but it is the aim of color-science to combine beauty with use in a very high degree. The object of this paper has been to prove that a coöperation between color-science and illuminating engineering could considerably augment the three fundamental purposes of illumination, namely, utility, beauty, and hygiene.

We could coöperate to bring people to realize the physical benefit and nerve-repair to be obtained from mobile lighting. They might learn to vary the color screens in their rooms as they now vary the hanging of pictures. Indeed, these decorative illuminations may take the place of pictures in many homes where it is not possible nor suitable to collect antiques. In the future these first expressions of a new art-science may themselves be called " antiques "! Who knows, save Time, that strange wizard, who doles out the mysteries of space no sooner than we are ready to receive them?

I have always felt a strong analogy between the American and the Greek republics, for the great American public is as vital as the great Athenian public was in its demand for variety and beauty in every expression of life. Therefore, with ardor I commend color-science, and invoke the coöperation of illuminating engineers.

JUNIOR SECTION

Dr. W. M. Boehm, Chairman *Ex Officio* H. I. Goldstein, Chairman A. P. Godsho, Secretary

THE regular monthly meeting of the Junior Section was held at the Club-house on Tuesday evening, March 12, Chairman Goldstein presiding.

The appointment of Mr. McCambridge as chairman of the Finance Committee was announced.

Mr. Boettcher, chairman of the By-Laws Committee, has the matter of increasing the age limit in hand, and will report the results at the next regular meeting.

Mr. Bittel, chairman of the Club and Public Relations Committee, gave a *résumé* of what had been done by his committee since the previous meeting. A letter addressed to Mr. Yarnall asked him to present before the Board of Directors the resolution adopted at the last meeting of the Executive Committee, asking for Junior representation upon the Board. The Board meeting having been held the same night as our own meeting, the decision will be announced at the next regular meeting of the Junior Section.

Mr. de Macedo, chairman of the Nominating Committee, announced that Mr. W. Z. Kline was the candidate selected for chairman for next year. Mr. Kline is well known among the Junior body, having been very active since its inception, and last year it was his paper that won the prize offered for the best Junior paper. It was decided, for several very good reasons, to leave the selection of next year's secretary in the hands of the chairman, so no candidate for this office was proposed.

Mr. Godsho read a summary of the Junior membership campaign, in which forty-six new Junior members had been elected and six applications are still pending.

Two papers were presented at this meeting:

"Crucible Process of Making Steel," by Mr. A. de Macedo.

"Waste Heat Boilers," by Mr. M. G. Bittel.

Mr. de Macedo gave an outline of the developments of this method of making steel from the time of Robert Huntsman, who made the first crucible steel in 1740, up to the present time. His paper resolved itself into four parts: The Process, The Crucibles, The Methods of Handling, and The Types of Furnaces Used. The process consists of melting high-grade materials in clay or graphite crucibles to obtain a definite predetermined grade of steel. The crucibles are of clay or graphite, the latter being generally used in this country. The crucibles are packed with metal in proper proportion and placed into either one of three types of furnaces—coke, producer gas, or oil-fired. The older furnaces were rectangular, below floor level, and regenerative. The more modern furnaces are regular melting furnaces in which the pots are stood upright, thirty or more pots constituting a heat.

Mr. Bittel showed the methods employed in generating steam from waste gases from industrial furnaces. He first gave a brief outline of the general laws of heat transmission, and showed how the heat transfer rate was greatly increased by high gas velocities over the dry surface of the tubes; showed why older installations were failures, due to the non-observance of this law of heat transmission. He explained how these high velocities were obtained in modern waste heat boilers, and then showed the application of waste heat boilers to open-hearth furnaces, which represents by far the most numerous and best type of regenerative furnace and from which the gases are drawn at a low temperature. He showed tests of these boilers made in several steel plants, and gave some figures showing the results and economies. In conclusion, he stated that this type of boiler had proved so eminently satisfactory that, in his opinion, any open-hearth furnace large enough to give a satisfactory gas flow, and not equipped with one, was an economic crime.

The next meeting will be held Tuesday evening, April 9, 1918, at 8:15 o'clock. As there is important business to be brought up, it is necessary that as many Juniors as possible be present.

The election for next year's chairman will be held, and two of the committees have reports to make which vitally affect the welfare of the Section. So all are urged to be present.

The paper for the evening will be:

"Standardization of Steel Mill Building Construction," by Mr. R. B. Nicholson.

The time limit for presenting papers for the Junior Prize has been extended from April 1 to April 15. Up to the present time there have been only two papers presented in the competition. Three more have been promised, but with the extension granted there is no reason why there should not be at least a dozen papers for the judges to compare and choose from, and anything which interests one person, if well expressed, will interest many. If every Junior would just write a few pages about his own particular work there would be a large number of interesting papers and the competition would be keen enough to make an interesting job for the judges; besides, this would help the Junior movement very materially by favorably impressing the Senior body. So let every Junior change some of his potential energy into kinetic, give some velocity to a pen point, and give the Seniors a good demonstration of Junior "pep."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS ∴ PHILADELPHIA SECTION

Lewis F. Moody, Chairman. John P. Mudd, Secretary, Midvale Steel Company, Nicetown, Pa.

FEBRUARY MEETING

To a very appreciative audience on February 26, Mr. Carl Barth gave his paper dealing with the Federal income tax. Mr. Barth pointed out the unevenness of the gradations in the present law, and suggested that the law be amended to smooth them out. The obvious means would be by a very simple algebraic equation. The rather illogical condition existing in the present law would have been partially corrected had the amendment offered by Senator Smoot passed. It had been hoped that Senator Smoot would be present; unfortunately, he was not able to come.

The title of Mr. Barth's paper has misled some of those who had not read it. It concerns or criticises in no way the idea of an income tax or the amount of the tax imposed. It has to do merely with the steps or gradations by which higher incomes are taxed a higher percentage.

Mr. Wilfred Lewis presented some very interesting suggestions in regard to differential rates of taxation. Messrs. J. C. Parker, Hugo Bilgram, H. L. Benner, and T. M. Chance also participated in the discussion of Mr. Barth's paper. The paper was indeed a treat, and those who did not have an opportunity to be present may look forward with much pleasure to the paper being published both in this Journal and the *A. S. M. E. Journal* in New York.

An important committee meeting of the Philadelphia Section was called by Mr. Moody for Friday afternoon, March 22. This meeting, of course, will have been held by the time this Journal reaches the members. The subject for consideration is the March and April meetings of the Section. Plans are being made for a joint meeting with the Engineers' Club in Witherspoon Hall on March 27.

Dr. S. W. Stratton, Director of the United States Bureau of Standards, has promised the Philadelphia Section a paper during this season, and it is probable that arrangements will be made for him to address the joint meeting. The subject will be "Notes on Accurate Measurement: Their Relation to Successful Munitions Manufacture."

The subject or speaker for the April meeting is at the present writing not determined. A special invitation has been extended to the Council of the National Society to attend this meeting. The meeting will be preceded by a dinner in the new dining-room of the Engineers' Club. It is hoped that all those who attend the meeting will be present at the dinner. The price will be one dollar per plate.

Among those on the committees for the next two meetings are: C. N. Lauer, L. C. Reynolds, J. W. Bressler, W. D. Disston, W. L. Fitzgerald, P. P. Henshall, L. L. Hepburn, H. H. Ingersoll, E. P. Priebe, H. E. Simpson, H. Tilson, R. C. Clarkson, C. W. Larner, L. H. Kenny, E. B. Carter, W. R. Jones, H. B. Taylor, C. Davies, H. H. Eselstyn, Leo Loeb, J. C. Shaw, W. H. Kavanaugh, J. E. Fulweiler.

SOCIETY OF AUTOMOTIVE ENGINEERS

PENNSYLVANIA SECTION

John W. Watson, Chairman A. K. Brumbaugh, Secretary, Autocar Co., Ardmore, Pa.

MARCH MEETING

On March 28th, at the Engineers' Club, the Pennsylvania Section of the Society of Automotive Engineers stood sponser for one of the biggest free-for-all discussions which has probably ever been held in this country by any engineering society.

The paper was by Mr. Landis, of the Landis Engineering and Manufacturing Company, Waynesboro, Pa., who gave us a paper on "Shock Absorbers as Affecting Easy Riding of Passenger Car and Ambulance." Mr. Landis treated the subject of shock absorbers in a very broad way and touched upon every known type of device which has to date made an appearance on the market. Mr. Landis took up each of these types separately and showed their value in aiding and controlling the action of vehicle springs in accordance with the conclusions, as to the limitations of vehicle springs, arrived at at a previous meeting of the Pennsylvania Section. At this previous meeting it was found that vehicle springs, unaided by auxiliary means, could not function properly in maintaining straight line travel of the body while the wheels were encountering road obstructions.

Taking part in the discussion of Mr. Landis' paper at this meeting were Ernest Elentje, Ed. V. Hartford, Claud H. Foster, of Gabriel Snubber fame, as well as the engineers of the Houdaille Company, the Westinghouse Air Spring Company, the H. W. Johns-Manville Company.

TECHNOLOGY CLUB OF PHILADELPHIA

H. A. Terrell, President. N. A. White, Secretary, Wenonah, N. J.

APRIL MEETING

THE next meeting of the Technology Club will be held on Wednesday evening, April 3, 1918. Mr. R. E. Page, '06, of the Philadelphia Manufacturers Mutual Fire Insurance Company, will speak on "Fire Protection." The paper will be illustrated by lantern slides. This will be the annual meeting of the Club, and officers for the ensuing year will be elected. There will be the usual informal dinner at 6:30 P.M. and meeting at 8:15 P.M. There will be a meeting on May 1, and the annual Field Day, the date of which will be announced later. No meetings are scheduled for the summer months.

MARCH MEETING

At the March meeting Mr. H. L. Moody, '07, of the Westinghouse Company, gave a talk on "Steam Turbines, Condensers, and Mechanical Stokers." The paper described the various types of machines, and was illustrated by lantern slides.

PHILADELPHIA SAFETY COUNCIL

LOCAL SECTION No. 7 OF NATIONAL SAFETY COUNCIL

J. F. Conner, President

J. P. Mudd, Secretary-Treasurer,
The Midvale Steel Co., P. O. Box 1322

FEBRUARY MEETING

A VERY interesting and well-attended meeting of the Philadelphia Safety Council was held in The Engineers' Club, Monday evening, February 25. President Conner was in the chair.

The topic for discussion, "The Foreman in Plant Safety," was opened by Mr. Fred W. Keogh, of New York, editor of *American Industries*. The discussion followed, in which the following participated: J. F. Conner, of The United Gas Improvement Company; H. B. Harmer, of The Philadelphia Electric Company; Captain John S. Spicer, of the Frankford Arsenal; W. B. Place, of David Lupton's Sons Company; H. P. Weaver, of the Independence Bureau; C. C. Black, of the Department of Labor and Industry; L. J. Freund, of Hoopes & Townsend; Mr. Chapin, of the Pennsylvania Railroad; R. B. Duncan, of The United Gas Improvement Company.

A delightful diversion was furnished by talent from The United Gas Improvement Company. Several numbers by the Olney Octet elicited much applause. An accordion soloist was also very much appreciated.

The musical part of the entertainment was directed by Mr. R. B. Duncan.

The meeting adjourned at 10 P.M.

MARCH MEETING

The next meeting will be held on March 25, at The Engineers' Club, but, as this JOURNAL goes to press before that time, a full account of the meeting will appear in the May issue.

REMARKS ON THE OCCASION OF OPENING THE NEW DINING-ROOM, MARCH, 1918

(Continued from Page 204)

shadow, he forgot about my presence, and when I turned he was silhouetted against the open door. I saw him drop to his knees in front of the bell, and as I watched him I held my breath, because I thought I was intruding. As I watched I saw his lips touch the bell and then I heard him say, "God help me to make good." That boy was nearer the mother he had loved and lost, he was nearer to his God than he will ever be again, until he meets them both beyond the Valley of the Great Shadow. That is the spirit in which our boys are going over. I am an old-fashioned man, born of an old-fashioned mother, who believed in an old-fashioned God, and I believe the principles for which Old Glory stands are God-given and will be God-protected.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

EASTERN PENNSYLVANIA CHAPTER

George W. Barr, President
George Boon, Secretary

THE regular meeting of the American Society of Heating and Ventilating Engineers will be held on the evening of April 11, at the Engineers' Club. Mr. George A. Eagan will present a paper on "Vacuum Systems."

The Society held its third annual meeting at the Engineers' Club March 14, preceded by an informal dinner. No papers were presented, but we had as the guest of the evening Mr. Joseph A. Steinmetz, president of the Aero Club of Pennsylvania, who gave us a very interesting talk, informal in its nature, on the "Boys Over There and Over Here." He called the attention of the members particularly to the vital need of speeding up on all government work, and not only to do our bit but to do our best.

Dr. M. W. Franklin also gave an informal talk on "Efficiency," and called to the attention of the members the necessity of backing up the government in its campaign of conservation.

The annual election of officers resulted as follows:

Mr. E. T. Murphy, President
Mr. C. V. Haynes, Vice-President
Mr. A. P. Goldsmith, Secretary
Mr. H. P. Gant, Treasurer

Board of Governors
Dr. M. W. Franklin
Mr. J. D. Cassell
Mr. W. G. R. Braemer

Mr. George A. Eagan, a member of the Rotary Club, called the attention of the members to the good that would be done by the purchase of Smileage Books. Doctor Franklin also spoke along these lines and suggested the purchase of Smileage Books by the members present. It was very gratifying to announce that out of an attendance of twenty-five the sum of $110 was raised.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ∴ PHILADELPHIA SECTION

Nathan Hayward, Chairman
H. Mouradian, Secretary, 1631 Arch Street

APRIL MEETING

Date: April 8, 1918.
Speaker: H. S. Warren, Electrical Engineer, American Telephone and Telegraph Company, New York.
Subject: Electrification of Railroads in its Relation to Communication Lines.

MARCH MEETING

THE paper of the evening, "Progress in the Use of Electricity on Board Ship and in Shipbuilding," was read by Mr. H. A. Hornor, Consulting Engineer, Philadelphia.

Mr. Hornor gave a very interesting review of the history of shipbuilding in the United States, referred briefly to the progress made in the use of steam on board ship, to the possibilities of electric drive in connection with the new American merchant marine, and discussed somewhat more in detail the use of electricity for auxiliary machinery on board ship. The paper was profusely illustrated with lantern slides.

There was a lively discussion following the paper, participated in by Messrs. Clewell, Rittenhouse, Hunter, Thaw, Allen, Funk, and Mouradian.

ILLUMINATING ENGINEERING SOCIETY

PHILADELPHIA SECTION

Walton Forstall, Chairman **Unit Rasin**, Secretary, 1411 Widener Bldg.

THE next meeting of the Philadelphia Section of the Illuminating Engineering Society will occur on Friday, April 19. The subject of the meeting will be, "Progress in Illuminating Engineering During the Past Year." The speakers on this subject will be Mr. F. E. Cady, of the Research Laboratory of the National Electric Lamp Works, Cleveland, Ohio, who will speak on the "Progress in Electric Lighting," and Mr. R. F. Pierce, of the Welsbach Company, who will speak on the "Progress in Gas Lighting." A synopsis of this paper is as follows:

"A *résumé* of developments in the art and science of illumination as portrayed by articles in the technical and scientific press. Among the subjects touched upon will be light-sources, including gas and accessories, arc and incandescent electric lamps; fixtures, including globes, reflectors, and supports; developments and conditions caused by the state of war; exterior and interior illumination; photometry, photography, and physics. The lecture will be illustrated by lantern slides; but, owing to the diversity of subjects treated, it will not be possible to elaborate on individual topics. References will be available so that those desiring further information on any particular point can ascertain where to look up the original statements."

After this Mrs. Mary Hallock Greenwalt will give a short discussion on "Mobile Lighting," having as her subject, "Can Different Intensities of Lighting Lend Emotional Significance Within an Amphitheatre as They do Nature?"

The March meeting of the Philadelphia Section occurred on the 15th and was preceded by the usual dinner, at which twenty-six members and guests were in attendance. Preceding the regular speaker, the Chairman of the Membership Committee announced that they had obtained thirty new members for the Section, with the prospects of at least ten more. Mr. Lyon then gave a talk on "The Nomenclature of Illuminating Engineering," with special reference to intensities distributed over the surface of a sphere, and he used as his model a wooden ball cut into zones to illustrate it.

Mr. S. E. Doane, who had expected to deliver a paper on "The Æsthetics of Street Lighting," was prevented from attending, and he sent as his representative, Mr. M. Luckiesh, physicist of the Nela Research Laboratories at Cleveland, who spoke on the same subject. His talk was profusely illustrated by means of lantern slides, showing uncommendable forms of street lighting and means of supporting trolley wires, etc. He showed street scenes, in some American towns, where the combination of poles and wires was a disgrace and marred what might otherwise be attractive streets. His discourse was a plea for the improvement of civic conditions by removing intrusive sign-boards and unnecessary trolley, electric light, and telephone poles.

The meeting was attended by ninety-eight persons, and, following the speaker, there was considerable discussion, which was not confined strictly to the subject of street lighting, but extended to methods of distributing overhead wires.

WORCESTER TECH CLUB

George A. Denny, Chairman **Robert M. Barr**, Secretary, Land Title Building

THE annual meeting and banquet of the Worcester Tech Club was held at the Engineers' Club, Thursday, March 7, 1918.

Dr. Ira N. Hollis, president of the Institute; former Judge Charles V. D. Joline, of Camden, N. J., and Professor Thomas, of the International Shipbuilding Corporation, were guests of the Club, and addressed the members.

A business meeting, with election of officers, preceded the dinner.

The following were elected officers for the year 1918–19:

	Executive Committee
A. H. Allen, President	
A. W. Baldwin, Vice-President	Norris W. Pease
R. M. Barr, Secretary-Treasurer	F. C. Gurley

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-5 MAY, 1918 NO. 162

"SOME OF MY OBSERVATIONS IN FRANCE"*

By MAJOR W. A. GARRETT
ASSISTANT GENERAL MANAGER, REMINGTON ARMS COMPANY

SHORTLY after the visit to Washington of the French statesman, Rene Viviani, and that wonderful French soldier, Marshal Joffre, our War Department decided to send a commission to France to study the French railroads and report on their needs to take care of the American expeditionary force to be sent over under General Pershing. During war times there are certain studies for the government about which nothing can be said. However, the War Department has no objection to my relating "Some of My Observations in France."

We were commissioned as majors and wore the uniform from the time we left home until we returned. It was necessary for us to do so, because there were certain places in the war zone that even our secretaries could not visit.

Our commission consisted of four men—William Barclay Parsons, of New York, the engineer who built the subway, chairman, to give special attention to rivers and harbors; William J. Wilgus, formerly vice-president of the New York Central, to study maintenance of ways and bridges; Mr. F. de St. Phalle, of the Baldwin Locomotive Works, was to study locomotives and cars, and my study was transportation.

We were able to report in part to the Department in Washington that the railroads of France were in as good average condition as the average American railroads to-day, and they must be kept in that condition, because in war time it is just as important to have a first-class transportation machine as to have a first-class fighting machine. We had the word of French officers that the very moment the French railroads or railroads of any country in war time go down, just that minute the country having the defective railroads loses the war.

We went to France by way of England and spent four days at the British War Office. The British have a similar problem to our own; that is, to handle men and material from the west coast of France to the fighting line.

In England we found the conditions one sees in a country that has been at war. They are trying to economize and conserve in every possible way. Little notice cards are put on your table for breakfast, dinner, and supper, "Don't waste bread; if half a slice is enough, please cut the whole slice. Every one must save bread; it is a national duty. Will you help?" The difference between England and the United States at the present time is this: The situation is serious and England knows that to be true, the United States does not yet know that to be true. We will know it soon. Lloyd George recently said that the Allies must either "go on or go under," which to every thinking man in this country means, Wake up, America! Speed up!

We went to France by way of Folkestone and Boulogne. We reached Folkestone forty-eight hours after a German aeroplane had been overhead and killed thirty-eight people, principally women and children. Aboard ship at Folkestone we were required to put on life preservers, and wore them from the time we left England until we reached France. Our ship was convoyed by two torpedo-boat destroyers on each side.

We reached Boulogne just two weeks from the time we left America, and this is the impression I received. As we left America there appeared everywhere on the billboards and placards "Enlist in the Army. Join the Navy. Your country wants you." In England, everywhere billboards—placards, on the streets, wagons, hotels, reading: "Economize. Eat less bread. Conserve." Two in the war drama: In France, no billboards, no placards, every man, woman, and child working from early morning until late at night, because the Germans had been in France, their country, for over three years. They had seen their own people killed, male and female enslaved, females worse than enslaved, their houses looted and destroyed, their streams and wells polluted, and the very ground upon which they live and from which they must get their living shot up to almost utter uselessness. War is just what Sherman said it was—*Plus.*

After visiting American Ambassador Sharp, we made an engagement at the French War Office to meet, the next day, Albert Claveille, the Minister of Railroads of

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* Presented before the Engineers' Club, at Drexel Institute, March 18, 1918.

France. He is a dictator, but it requires dictators to run all departments during war times.

After reaching France and presenting our credentials, it did not take us long to get into the real war atmosphere. The French people are not so much impressed with what the German Army has done as what it did not do, because on paper the Germans had the best gambling chance to win that any country could have after forty years of preparation.

That wonderful man, Marshal Joffre, recognizing the importance of transportation, lured the Germans on; as they came from the west coast he lured them back to the Marne, and then everything that France had was put into service. Von Kluck was held up, the first real stop the German Army had gotten since passing Liège and Louvain. We were told in France that the Germans were so sure of getting into Paris that when the battle of the Marne was fought they had left their big guns back in Belgium, and the biggest gun the Germans had was a three-inch. Joffre's handling of the railroads was such that the Germans could not get down the larger guns if they had tried. At that time the railroads of France gave a wonderful account of themselves. The automobiles and taxicabs from Paris brought out the soldiers, and the East line ran 180 troop trains of fifty cars each a day. The Paris Orleans system running to Bordeaux took down the archives from the War Office because the State Department was moved from Paris to Bordeaux when Von Kluck was approaching. This railroad brought north-bound the troops from the Spanish frontier. The Paris, Lyons and Mediterranean took the wounded troops to the French Riviera and brought up the Colonial troops from the opposite side of the Mediterranean. Sixty-five per cent of the Nord road was then in the hands of the Germans, and even to-day approximately 33 per cent. of the Est. road is in the hands of the Germans.

We went to the west coast and there studied port conditions and saw our first lot of German prisoners. The German prisoners in France are permitted to have a German officer in charge to give them instructions, provided the officer speaks French. In one camp the French were having built for the Americans, using German prisoners (a camp that would hold 8000 men and which has been used time and again by our boys after arriving at port), these German prisoners were putting in a water-pipe line. As we approached the German officer said something to his men and every man dropped his pick or shovel by his side, clapped his heels together, and the officer stood at salute. Make no mistake; the Germans are fighters from their feet to their heads, and we are not asked to go to France for a triumphant march to Berlin, but to go to France to fight every inch of the way, and the way is long and the way will be hard.

In Paris we stopped at the Crillion Hotel, on the Place de la Concorde—that most beautiful place in Paris. There is where the German Emperor said they were going to have the German troops take Christmas dinner in 1914. The Place de la Concorde is no place for the Prussian military caste. They never got there and they never will get there.

Paris is a changed town—a very much changed town. One could not order dinner after 8:30 o'clock at night, and he must finish his dinner by 9:30. No taxicabs on the street after 9:30. Mourning, mourning everywhere.

Over on the west coast we were able to study the treatment of the German prisoners. German prisoners in France get the same treatment you would expect those kindly French people to give. German prisoners in France are well treated.

The Pressed Steel Car Company here in America has orders to build a certain number of steel freight cars for the French Government. They are built in this country, knocked down, and sent oversea, and erected in France by the German prisoners. They were paying the German prisoners four francs for each day's work, with a possible one franc extra as a bonus, provided they did more than their day's work. We were told that 90 per cent. of the German prisoners were making the one franc extra.

We returned to Paris and went up to the northeast or the British fighting line. We saw the wonderful aggregation of British fighters from all over the world—England, Ireland, Scotland, Wales, Canada, Australia, West Indies, New Zealand. Before getting to that country it was necessary for us to go over the land from which the Germans had been shoved back. Germans never retreat; they must be shoved back. The ground from which they had been shoved back cannot be described. Joseph Pennell, the American artist, who was in France to sketch, said he could not do it; it was too nerve-racking. The ground is principally limestone and chalk. As the big shells hit the ground they tear up the bowels of the earth and, mile after mile, there is nothing but a quarry-bed—no trees, no grass, no dirt—shell holes everywhere, six to eight feet deep, with scum water, oftentimes of an indescribable color. In that district one is required to wear the steel helmet and carry the gas mask; the steel helmet because the airplanes are constantly overhead; constantly shooting, and the shrapnel going up, must come down; hence steel helmets to avoid head injury; gas masks because both sides are not only throwing gas but shooting gas shells. And then one sees hundreds of miles of shot-up trenches and thousands of miles of barbed-wire fences and entanglements, and the wonderful hospitals in charge of those splendid men and true, godly women. And then one sees the graveyards, hundreds upon hundreds, and thousands upon thousands of graves everywhere; white crosses, marking the Allies, black crosses, marking the Germans.

Let me tell you the difference between the manner in which the Germans have been fighting and the manner in which we propose to fight. The German Government sent out postcards by the thousands, because hundreds of them have been taken from the German prisoners, and the postcard reads: "You will take no prisoners. Show no mercy. Show no quarter. Make yourself as terrible as the Hun who said, 'Where our footsteps fall let no grass grow for a thousand years.'" The German soldiers are trying hard to carry out the order, and are doing the job well. This is what General Pershing has put out: "Your first duty is to be soldiers; your second, and scarcely less important, to help those who are poor and weak. You will be courteous to all women. Abstain from wine and liquor. Be kind to little children. You will fear God and honor your country and win the war to liberty. God bless you and keep you."

Our commission did not witness any German atrocities; that was not our study. But there are commissions in both Belgium and France, composed of scientists and learned men, who are taking the historical record, by sworn statement and photographs, so that when the time comes over the long-table conference, with Germany on one side and the Allies on the other, there will be an accounting from which there can be absolutely no escape for the Germans. Our government, recognizing some of these conditions abroad, printed a book in January last, giving some of the historical records of the German atrocities, and in this book they have shown forms taken from a war book. These forms were printed in 1906, and all that was necessary was for the German officer to insert the amount of money he wants to commandeer and the date, the name of the town, and other data. In this book, too, there is something that the labor leaders in this country should read, because there is a petition from the Comité National in Belgium to the late Governor, General Baron von Bissing, who was in charge of Belgium—an appeal not to deport their workingmen into slavery back into Germany. Everywhere you will find the evidence in Belgium and France of German atrocities, and if the American people could only visualize the invasion of Belgium and the desecration of France and the assaults upon the daughters and the wives, the mothers and the grandmothers of our Allies, there would be no need in this country for a Liberty loan, because there would be a *voluntary gift* by our people to crush out German militarism and make the world a safe place in which to live.

We were asked to go to the British headquarters at Montreax. We did not meet Sir Douglas Haig. He had gone over to Ypres a few days before.

We were asked to study the mobilization of troops under a drive. General Nash, who had succeeded Sir Eric Geddes, is now commander of the British transportation in France. Here we saw train after train of good, clean men about six miles back from the firing line to-day going North, happy and smiling, and tomorrow coming back in the ambulance trains, and many of them never coming back! The British and French are at all times trying to get their men and material as near the fighting line as possible on the standard-gauge steam railroad. We were asked to go to Vimy Ridge to see the transportation program they had, but the Germans found what the British had built before we reached Vimy and the Germans had been shooting it up with big shells. It has never been my privilege to be in a country where big shells were coming toward me. Altho I have stood on ground and at sea alongside of big guns being fired, there is a difference between shells coming *toward* you and shells going *away* from you—quite a difference.

About sixteen or eighteen miles north of Vimy Ridge is Lens, the great coal district of France. The Germans have taken the entire northeast district of France—the Pittsburgh district of France—the coal mines, steel plants, and iron foundries. The British have been trying to get back Lens for some little time, because the Allies are short of coal. We are impressed when we read in the papers that the Germans have been shoved back 200 or 400 yards, but it is just 150 miles from Lens to the German frontier.

We went to Arras and went east from there on the 60-centimetre military track to see the big 13-inch guns being fired under airplane instructions. After having fired the sixth shot they said they had hit the bull's-eye. I asked what it was, and was told that they were shooting up a railroad junction nine miles ahead.

Ex-President Taft had this to say recently in the Philadelphia papers when trying to impress the American people with the fact that we are at war: "We should furnish facts and not figures of speech. We should make arguments and not declamations. The vital importance of winning the war grows stronger with us as the difficulties impress themselves more seriously upon us, but it is time we should feel in our hearts what confronts us."

Now let me give you a study-picture, no declamation. The British are protecting in the northeastern part of France approximately 125 miles of fighting front from Belgium into France, and the average distance between the British Channel and the British fighting line is approximately fifty miles. Where we, the American troops, fight, because of port conditions, military conditions, and other conditions, it is over 400 miles from the coast to the fighting line. Anyone can understand that to handle men and material 400 miles you must provide approximately eight times the transportation machinery that you would on a fifty-mile haul. Now what have the British? They have 750 British locomotives in France; 49,500 British freight cars in France; 98,620-odd transportation men for a fifty-mile haul, and we have a 400-mile haul. The British also have on this fifty-mile fighting front over 200,000 laborers of twelve nationalities to unload ships, work upon the railroads, highways, canals, supply stations, and railway yards. In other words, 200,000 laborers and 100,000 transportation men for a fifty-mile performance, and *we* have a 400-mile performance. The American people have absolutely no thought of what they are up against. When the second Liberty loan came out Secretary McAdoo announced that nine and a quarter million people had subscribed. Less than ten per cent. of our people thought sufficient of the war to lend our government money. When they get the third, fourth, fifth, sixth, seventh, eighth, ninth, and tenth loans, more of our people will loan the government money, because if Germany ever gets a toe-hold here it will not be a Liberty loan, but a German grab, as they made in Belgium, as they did in France, and as they are doing to-day in Russia. "Oh," people say, "yes, we knew we were at war when Director Garfield said something about coal. Yes, we knew that we were at war when a transport went down off the northeast coast of Ireland and we lost more than 200 of our boys." We will know, however, that we are at war when we see cripples, cripples—everywhere, and when our hospitals are absolutely full to overflowing, as they will be *then*—we will appreciate we are at war—and when your boys don't come home, then you will ***know*** that we are at war.

General Gorgas said at Witherspoon Hall the other night that if we have a million fighting men in France he would want 250,000 cots in France, and if we had a million fighting men, 100,000 of those men will come back here every year, never able to fight again. He said nothing about the boys who will forever stay over there!

When in France we were asked to go to French headquarters. General Petain wanted to talk to the people from America about transportation. When Marshal Joffre was relieved, at his own request, he was succeeded by General Nevielle, and the latter was succeeded by General Petain, who won his spurs in the defense of Verdun. We were asked to take luncheon at General Petain's headquarters. We had a wonderful lunch. We had soup—French soup—and fish fixed French style, potatoes and peas and some goat cheese, coffee, large strawberries, and native wine, but General Petain had no butter; he had no sugar; he had no milk. General Petain told us about Verdun. He was at Verdun when the Crown Prince made the attack, one of the greatest attacks the world has ever known, because Emperor William wanted to have the Crown Prince do something worth while. General Petain decided to hold Verdun, and he issued the famous order, "They shall not pass—Petain," which is still painted on the fort at Verdun. General Petain said as soon as it was decided to hold Verdun they decided to do three things: First, to build a thirty-six-mile double-track railway from Fleury to Douney, and it took 60,000 men three months to build it; had they been ten days longer they might have lost Verdun. Then they had a narrow line of three feet gauge, and they decided to make that a double track. He telephoned to Albert Claveille for engines, and that afternoon locomotives and narrow-gauge cars started toward Fleury. The call was so urgent that they left the passengers and freight standing out in the country; the engines were run to the end of the narrow-gauge line, loaded on flat cars, and the engine, with steam up, taken to the point that they wanted to unload. Then they had a pike of not sufficient width for two automobiles to pass, and they decided to make that a double pike. Northbound automobiles going to Verdun with men and material had the right of way. Southbound had orders to run to Station "A," wait for two northbound; to Station "B," wait for four northbound; to Station "C," wait for three northbound. They were to maintain a speed of twenty-five kilometres an hour, and if they could not maintain that speed, to run their automobiles off the pike and clear the line; and that is the way they defended Verdun, a town of 11,000 houses, into which the Germans day after day put in 600 shells each day, one every two minutes. You can image what there is left at Verdun. There are three forts at Verdun—Souville, Douimou, Voux. We crawled over the front of Souville Fort and looked across the valley where the Crown Prince of Germany lost over 500,000 men trying to take Verdun.

In each German regiment they have what they call a "hellish squad." The duty of the "hellish squad" is to poison wells and to connect with electric batteries every movable thing. Thus: Lift a chair and bombardment; open a door and bombardment, and generally people killed. The "hellish squad" also is doing its work well.

When war was declared in this country in April last all the railroads in this country decided to put the management of the railroads in the hands of six railroad presidents to be located at Washington. That was continued until December 28, when the President very wisely created the position of Director General of Railroads. The people of the United States will regret the day if we ever have government ownership of railroads, but during the period of the war government management is necessary, because the railroads need money now for engines, cars, and additional facilities, and money can be provided by the government better than by private management; and then the people of the United States will stand for less passenger train service and ride standing up with better grace in passenger trains under government management than under private management.

When war was declared in England all the railroads were put into the hands of Sir Guy Gannett, and passenger rates were raised 50 per cent. and that automatically took off 40 per cent. of the passenger train service. They also raised the freight rates 50 per cent., so that to-day in England the freight rates and passenger rates are 50 per cent. more than what they were in 1914, the government guaranteeing the same net earnings every year during the war that the railroads had in 1913, which was the "peak" net earning year of the British railway lines. In France they did not raise the freight or passenger rates, but during the last few days the papers have announced that the passenger fares in France will be increased 25 per cent. However, Albert Claveille took off 60 per cent. of the passenger trains immediately. In Paris we met two Americans at the American express office and they said: "We are glad to see American officers here. We understand there is a commission at the Crillion Hotel which has come here to tell the French people how to run their railroads." I said, "What is the matter with the French railroads?" They said: "They are rotten. We stood up from Brest to Paris the other night." We told that to Claveille that afternoon, and he said, "Oh, yes, we only took off 60 per cent. of our passenger train service; we should have taken off 75 or 80 per cent. These are war times, and we will have to win or lose the war with these railroads." Get this thought in your mind: Every soldier in Europe to-day rides in box cars and on flat cars, and if there is any complaint about our passenger car service in this country, keep that fact in mind. Our boys are not only willing to ride in box cars and flat cars, but also willing to lose their lives for their country. It is very easy to die on the field of battle, but these boys are also willing to be cripples, and possibly suffer every minute of their waking hours, to help win our war. And these railroads in our country between Buffalo and the Pittsburgh zone on the west and the Atlantic Ocean on the east are war railroads, and we have the same conditions to meet as they have in France, where to-day the only people riding in passenger trains are those on errands of mercy and on war business.

The food situation in certain parts of France is very critical. There are few people in this country who understand what that splendid man Hoover is trying to work out. Hoover is not trying to save you the cost of living expenses, but to conserve the food to prevent starvation in Europe and here. Our boys are over in Europe right now. We should always think of them in trying to conserve food here to help us win the war.

The French people are very tired. They have fought the war for over three years. They have lost over 1,300,000 men killed, and you cannot tell how many men crippled—crippled—crippled!

All that France can give our people to-day is three things—air, water, and standing timber. Claveille said: "Don't send any bridge timber, dock timber, or railroad ties. Send your foresters over to cut our standing timber." When the transport went down off the northeast coast of Ireland recently, the papers announced that some who were lost belonged to the forester regiment.

The coal shortage is a serious thing in France. When we left Paris coal was selling for $45 per ton, and you could not get the full half ton that Doctor Garfield gave you last year.

It had never been my good fortune to meet General Pershing until I was in France. He endeared himself to the French people because he went to the tomb of Lafayette and said, "Lafayette, we are here!" Four words, and then the French people knew that the American commander was a man of action and not of words. After the several conferences I had with General Pershing, I believe General Pershing is absolutely the right man in the right place and will give a splendid account of himself and our boys "Over There" at the right time.

We came home on the steamer *Espagne*, and on board the ship were the remnants of two crews which had lost their ship by a German submarine. The submarine is a real menace, make no mistake.

Our ship program is a very serious one; in fact, *the* situation during the war. To feed an army of a half million men and the horses for a half million men and the guns for a half million men requires three ships a day—one every eight hours. For a million men, a ship every four hours. For four million men—and we will have four million fighters in France before we are thru—one ship every hour from the United States to France, and every ship must run the blockade to get there. A trail of smoke between the United States and France. First we must get our army over, and this will require ships, and then we must send supplies to feed them. Then we must have more ships to take our locomotives. The British have 750 locomotives on French rails for a fifty-mile haul, and we have a 400-mile haul. Then we must have ships to handle our freight cars (the British have 49,500 for a fifty-mile haul, and we have a 400-mile haul). Then we must have ships for our rails, our machinery, and then we must have ships for the foodstuffs and ammunition for our Allies.

One is very much impressed in France with the military thoroness of the Germans. Before they are shoved back they loot and destroy absolutely everything. I saw a ninety-foot bridge in which they had put six dynamite charges. *One* would have done the trick. If they cannot take the rails back into their country, they put dynamite charges in the rail joints and rip the rail from end to end. If they cannot get the ties back into their country, they are piled and burned.

Until we reached Peronne, to-day in the hands of the British, I was of the opinion that the destruction of trees was a military necessity. At Peronne I was satisfied that was not true. The station is about half a mile from the town, at the foot of a hill. Between the town and the Nord Station there was a magnificent boulevard with a bridge crossing the Somme, and on either side of the boulevard trees fifty or sixty years of age. The Germans had deliberately cut each tree three-quarters thru with an axe; every tree standing and every tree dead. I am now satisfied that destruction of trees is not always a military necessity.

We are getting many sidelights from Secretary Lansing showing what the Germans were doing to us prior to the war and since the war. They told us in France that regiment after regiment of Russians was compelled to fight with sticks and stones and crowbars, and Von Hindenburg mowed them down with machine guns by the thousands. Then Russia supplied an army with good guns and was on its way to Vienna and would have gotten there in six weeks' time. Then came that abominable situation in Petrograd, cutting off the ammunition, then the foodstuff, and two million of them left the trenches and returned home. Prussian military thoroness!

We were told at French headquarters that, prior to the war, Germany had a population of 65,000,000 people, but now "we absolutely know that the German census had been faked for years, and that the population of Germany was 100,000,000 people." Prussian military thoroness!

Get this thought: Germany is a manufacturing country while France is an agricultural country *per se*. When war was declared there were 55,000 French freight cars in Germany; only 17,000 German freight cars in France. Germany was 38,000 freight cars ahead. Prussian military thoroness!

At one of the French west ports filled to overflowing with wagons, automobiles, and aeroplanes, built by the French people for Russia, we were told that some of these wagons came down thru the back way, around Archangel, and were captured by the Germans ninety days after they left the west coast port of France—Prussian military thoroness!

In France you will find everywhere in public places this sign, in French, reading: "Keep quiet. Don't talk. The enemy is listening too." A very wise precaution there and a very wise precaution here.

We have some very well-posted, brainy captains of industry in this country, who think America is in real danger at this time, but, we should not permit camouflaged Bolshevik, I. W. W.-ism, or any other ism, to interfere with our war program. There is only one of two positions for every man and woman in this country—either *with us* or *against us.*

"*Results*" is the only language we can understand during these war times. Yes, we will make mistakes. Any man, any company, or any country which "does things" makes mistakes, but, thank God! the British fleet and Admiral Sims and our boys are holding back the German fleet, and, thank God, that western line will never be broken by the Germans! It might be bent, but *it will never be broken.*

The women in France and England are doing wonderful things. They have responded nobly. I had never seen such manual work performed by women as was being done in France. We saw women doing manual work and such labor as women should never be called upon tò do. I have never seen women trucking freight in freight-houses. There is no such thing as a freight-house man or a baggage man in France. They are all women. Over 46,000 women are working on the French railroads. In England they have what is called the "British Women's Army Auxiliary Corps," and they are getting approximately 50,000 women to be sent to France to act as clerks, cooks, and chauffeurs. The American women—God bless them!—they will do the right thing when they know the job before them, and the job is there.

Since relating "Some of My Observations in France," I am charged with being a pessimist. I always thought I was an optimist. I know that I was an optimist before the war. My idea of a wartime optimist, however, is a man who states the facts as he knows them, and, if the picture is bad, tries to inject "Americanitis" into every man and woman to help change the picture. Stating facts, to my mind, is not pessimism. The American people never have failed to do the right thing when they knew the job ahead of them. But one way to lose is to underrate your enemy. My father was a birthright Quaker, but, having seen France, I am absolutely certain that we should have in this country universal military training.

Will we win the war? Yes! Just as sure as the sun rises in the east, *because we must.* How long will the war last? Until we win. Our government, however, has very wisely mapped out a program for a long-time war. But consider the bigness of the war. Money by the billions, men by the millions, ships, aeroplanes, and cars by the thousands. Our war program is the biggest transportation program that the world has ever known. Our Director-General, William Wallace Atterbury, vice-president of the Pennsylvania Railroad, must have the biggest supply yard the world has ever known in France, and he must have it because he is 3200 miles away from home. The biggest railway supply yard I have ever seen is the British one in France, but they are only a thirty-two-mile water trip across the English Channel whereas we have 3200 miles of water to cross.

In conclusion, after traveling approximately 4000 miles over French railroads, 1000 miles in automobiles in the war zone, visiting the British headquarters at Montreax, French headquarters at Compiegne, east of Arras, among the thirteen-inch guns firing under aeroplane directions, at Vimy Ridge under bombardment, in the Champagne District, among the camouflaged French guns, and at Souville Fort, Verdun, watching the bombardment from the fort parapet and witnessing sights which can never be blotted from one's memory, this is my message to those who stay at home: Economize. Don't waste. Be an American first, last, and all the time. Let your criticism of our war program be *con*structive and not *de*structive; stand behind the government and ask yourself each day, "What am I doing to help win this war?" And for those good men and true women who go abroad to win our war, Good luck and God bless them!

THE INFLUENCE OF TOPOGRAPHY UPON THE STRATEGY OF THE EUROPEAN WAR[*]

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ALMOST every one who has written on this subject has begun by saying " Never since the very dawn of history." And really this war has been exceptional and startling in so many ways that this is not a bad way to begin. It is appropriate for most purposes. I shall begin with exactly the opposite wording of the same phrase: Ever since the beginning of history the movements of troops and the winning of victories have been in very large measure controlled by the topography of the country over which the wars were fought.

Carry yourselves back in imagination into the past a length of time that is not very great from the point of view of the geologist, but which is very great indeed from the point of view of the normal human being—a matter of some tens of millions of years. At that time, in northern France, where to-day there is a broad, open country, richly fertile, there stood a mighty mass of mountains beside which the Alps were at least no rival, and that mass of mountains, if given plenty of time, would be worn down gradually by the rivers that flowed over them. The hardest rock can be worn away. Give time to the patient frost and running water gradually to destroy it, turn it to dust, move it away to the foot of the mountain, carry it as mud within the rivers, lay it down again on the flooded plains, pick it up again until it finds its ultimate resting-place somewhere out in the sea; the hardest rock can be worn down, the highest mountain can be leveled. And if one could watch those mountains thru countless generations of human lives, one would see the rivers cut deeper and deeper, the mountains wear to hills, the hills to low, rolling country. And so the highest mountain that stood in France at that time came, in the course of time, to be worn down to something like a plain. Then, watching still, you would have seen that plain subside gradually beneath the sea. Such movements of the earth's crust are going on all the time, but too slowly for our human lives to span them. They go on too slowly for the oldest legends that we reach to bring us any knowledge of the time when there were continents where the sea now flows.

THE BROAD, FLAT FLOOR OF THE MIDDLE RHINE VALLEY, AS SEEN FROM THE FOOTHILLS OF THE BLACK FOREST MOUNTAINS

There came such a time in northern France, and

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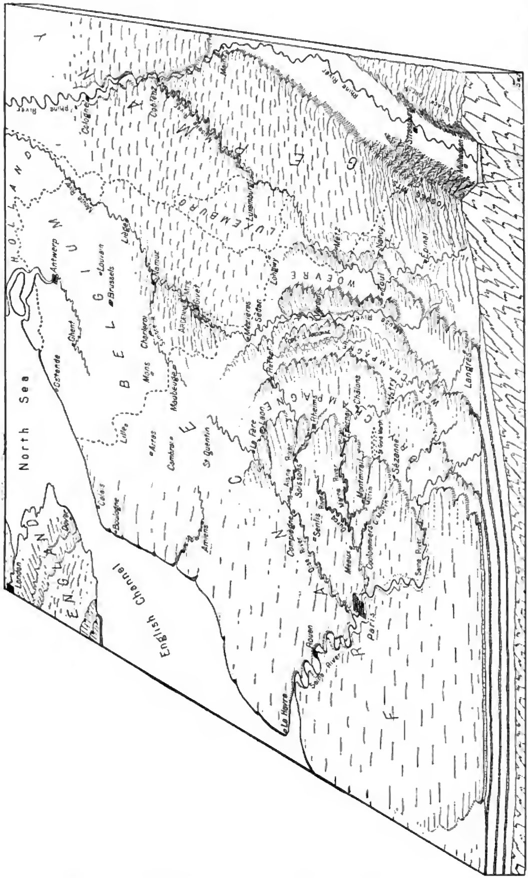
[*] Presented before the Engineers' Club, at Witherspoon Hall, February 15, 1918.



DIAGRAMMATIC VIEW OF THE WESTERN THEATER OF WAR, SHOWING THE PRINCIPAL PLATEAUS AND PLAINS, MOUNTAINS AND LOWLANDS, CLIFF SCARPS AND RIVER TRENCHES WHICH HAVE INFLUENCED MILITARY OPERATIONS. THE UNDERGROUND ROCK STRUCTURE IS SHOWN IN THE FRONT EDGE OF THE BLOCK the sea rolled in over the land, and in that sea there lived countless numbers of shells and animals with no earthly idea of what was to take place on the soil of France later on. They lived their lives and died their deaths and left their little palaces to accumulate until layer after layer had formed great beds of limestone. Rivers from the land still left standing brought down countless particles of mud and spread them out in great sheets upon the sea bottom. So, where the tops of mountains had towered in the first stage of this story were now vast, smooth sheets of sediment, sands, clays and limestone, beneath the sea.

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THE ROLLING HILLS OF THE LIMESTONE UPLAND. THE VIEW LOOKS NORTHWARD TOWARD HAUCOURT—A PART OF MALANCOURT VILLAGE. IN THE DRAWING ON PAGE 232 THIS SCENE EMBRACES A LITTLE DEPRESSION WEST OF HILL 304, AND IN THE DISTANCE THE HILL BEHIND MALANCOURT

Then imagine an uplift, and that that region became lifted up above the sea, and not only lifted, but bent, for the mighty forces of the earth can bend rocks quite readily. In this case the rocks were bent gently upward on edge, so that they were folded into a kind of bowl. Imagine that these sheeted strata in northern France now formed a great saucer whose edges turned up in every direction. Then let the rivers again attack that region and begin to wear it down. Wherever there was a bed of hard rock, that bed tilting up out of the earth would give a steep cliff along its upturned edge. The rear side, which was on the flat, sloping face of the stratum, would be a very gently sloping smooth plane surface down which the waters ran.

The diagram Fig. 2 can be imagined to picture a slice cut out by the earth's crust. On its cut edges can be seen the warped and bent beds resting on the folded crystalline rocks that had once been the great mountains. Where hard beds come out of the earth cliffs develop, cut into by many streams; and where soft rocks are between two hard layers a broad, flat lowland will develop. So in a kind of circle around the northern part of France there developed a series of cliffs. Since all the rocks are plunging down toward the west in that part of France, the cliffs developed with their steep scarp facing toward the east, with a gentle slope down along the back of the stratum of rock. That was fortunate, because an enemy moving against France from the east would have to stop at each one of these cliffs and face the defender on the ridge. The enemy must pass across that open plain, and when the fight was won the defender could merely retire to the next ridge, which was like a natural fort, and from the top pour a torrent of steel toward the enemy. If the enemy still struck, the whole story was repeated at the next cliff. These ridges constituted the natural defense of Paris, for Paris lies at the center of these cliffs.

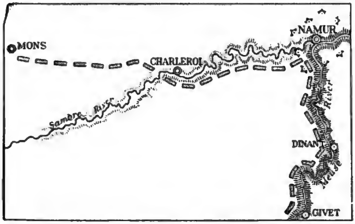
Nor was that the only defense of Paris. When this warping occurred that bent the soft rocks into a basin it was natural that the hard rocks lying underneath should be bent. On the other side of the basin these crystalline rocks were warped upward into an arch, but here a curious thing happened. Two long slits or breaks developed in the crest of that great arch, and the center block, like a keystone, sank into the earth. The slide was but a few thousand feet, and on either side stood a similar ridge of hard crystalline rock, facing outward upon the valley of the down-dropped block. On that flat floor of this valley winds the River Rhine, together with many other little rivers that traverse it, and on either side these tremendous cliffs of rugged steep rocks have been developed. The back slope from the western cliff toward France is very gentle, it having been cut by the rivers into a rough rolling topography which forms one of the great defenses of France. An enemy attacking Paris by way of the Rhine must fight his way up a cliff a thousand feet high—altho not a thousand feet sheer, for the rivers have succeeded in making it much more gentle than it formerly was. Toward the north this cliff dies down very much and lifts up again, so that a comparatively low country leads from the Rhine Valley into Lorraine, sometimes called the Lorraine Gateway. Railroads, roads and canals lead thru it to Lorraine. Farther north that gateway is stopped by a higher ridge.

Not only was there warping up in one direction, but northeast of the Paris Basin the lifting up of the strata into another arch permitted the rivers to wear away the soft rocks that lay on top of the hard ones, leaving the hard rocks standing out. The rivers that have rushed across these rocks have not been able to open their valleys out and make them broad and flat, but have cut deep, winding, narrow trenches thru the land, trenches that are exceedingly difficult passes for armies and exceedingly good defenses from the enemies.

At the north the Somme River and the Meurthe River wind their way thru the trenches, and the Moselle River, cutting its way thru in deep trenches, was again one of the very difficult gateways across which the Germans had to move. Unfortunately a great part of that was in the hands of the Germans, and the Lorraine Gateway was also in their hands. Both was their part of the victory of 1870–71.

Farther north those physical barriers die out into a great lowland that is in part below sea level; here there are no cliffs, but there are swamps and many rivers winding to the sea.

Bear in mind four types of topography. One shall be the region at the southeast, where the Vosges Mountains form one side of the broken arch and the Black Forest forms the other side; that is one unit. The second unit is the region of the low arch where streams have cut deep, narrow trenches thru hard rocks. The third is a region where the hard and soft strata alternate with each other, producing alternating series of cliffs and plains, with all the cliffs facing toward the east. And the fourth and last is the broad, flat, swampy, richly watered plain of Belgium and northern France.

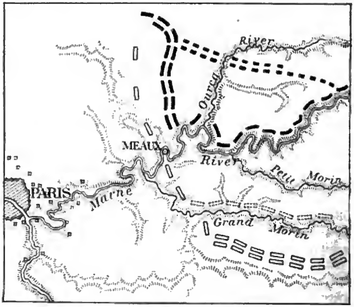


MAIN DEFENSIVE POSITION OF THE ALLIED ARMIES AT THE BATTLE OF MONS-CHARLEROI-NAMUR

Now if one were to conduct military operations against France and had the choice of one of those four countries to do it in one would believe that the broad, flat lowland of Belgium would be the best adapted to the modern need of moving armies rapidly by many parallel roads. The invasion of Belgium was determined not in the least, as alleged by our enemies, by any political consideration whatever or with any idea that the French had intended to attack the Germans thru Belgium, but because that country happened to offer an open gateway thru northern France. There were four ways of attacking Paris. One was to attack straight across the Vosges Mountains, beating the way thru the cliffs, one after another. There were not only the great breaks in the Vosges Mountains to aid the invader, but there were gaps in many of the smaller cliffs. Where rivers flow or formerly flowed thru those cliffs they made gaps which serve to-day as locations for railways and canals; all the railroads from Paris to Berlin pass thru these gaps, and as one goes from Berlin to Paris he sees one gap after another; he is first in a deep trench and then on a broad plain, and then in a trench again as he passes thru successive gateways.

In Fig. 1 one sees the broad, flat valley of the Rhine from the Schwarzwald on the German side. One of the little streams flowing down thru the hard crystalline rocks of the Schwarzwald is shown in Fig. 10. The river has had time in this part of its course to open up the valley which is richly cultivated, but the rocky slopes are unusable, except for forests. One of the reasons that it has the name of Schwarzwald is that it is densely covered with forests (Schwarzwald meaning black woods). On the side of the Vosges Mountains and near the edge of the great crest one can look down upon the plain, and see the main highways, winding their way painfully up the cliffs. Imagine trying to face such a cliff with the enemy on the top, where the ground is far more level. A story is told of a German general who was ordered to carry his army across the Vosges. He assaulted a cliff and was repulsed. He made three desperate assaults, one after another. He was repulsed in every one by the Frenchmen at the top. Then orders came directly from the Kaiser, telling him to carry the Vosges at all costs. He paid the costs with usury and failed to carry his army to the top. Then he returned to his tent and committed suicide. Before doing so he wrote a letter to the Kaiser, saying, "The Vosges Mountains cannot be crossed. If you doubt it, come and try it yourself."

A German writer said that the Vosges and the Schwarzwald lie on each side of the valley like two monstrous sphinxes, with their paws outstretched guarding the gateway to the Fatherland. These mountains, marvellously similar, lie one on each side of the valley, but just now it is France that the sphinx on the Vosges



Approximate German positions at the battle of the Marne. Solid line open rectangles: Mass of German armies south of Grand Morin, thin screen of troops facing west to protect right flank, at beginning of battle. Broken line open rectangles: Rearguard defending passage of the Grand Morin while bulk of troops are being shifted north to meet French attack on flank. Black rectangles: Main army facing west and seeking to envelop north end of French line, while screen of troops defend crossings of the Marne trench. Black dots: German armies withdrawing up the valley of the Ourcq.

THE FLAT-FLOORED VALLEY OF THE MARNE RIVER IN THE VICINITY OF MEAUX

side has guarded. On the one side lies the Vosges and the Schwarzwald mass, and directly across from that is a series of parallel ridges—ridge behind ridge, each one higher than the last, forming the Jura Mountains. Part of the Juras belong to Switzerland and part to France. The gateway that leads from the valley of the Rhine into the valley of the Saône is guarded by a tremendous fortified camp—Belfort. The region beyond the cliff is Besançon, which again is one of the forts. Here are the back slopes of the Vosges Mountains, and upon those slopes range after range lies, protecting the land which the French held.

Stand now upon one of these great cliffs, this time on the German side, and look out over the great flat valley of the Rhine; in the distance is the sphinx of the Vosges Mountains, which can faintly be seen. A wonderfully flat country is enclosed between those two great upheaved rocks. The only success the French have met in holding German territory has been near Mülhausen, where they could go down upon the flat plain of the Rhine.

In the arched region of the Ardennes, and the highlands eastward, the Meuse, Moselle and Rhine rivers have cut deep gorges that wind back and forth. Their tributaries have carved the smooth upland into a fretwork of smaller gulches. Roads must follow the winding rivers, because only here are there grades that permit heavy traffic. An enemy advancing along such a river gorge must conquer the rugged upland as he comes, to avoid being outflanked within the valley. A broad upland, of gentle rolling topography, cut by a thousand little trenches is one of the most difficult regions to fight across, more difficult than mountains like the Alps.

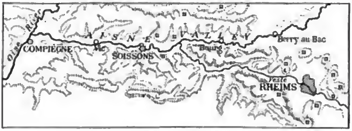
The Meuse and the Sambre rivers run together at the head of the great arch and then pursue their way out toward the Rhine, and guarding the head of it, just at the entrance where the two rivers join, is the great fortified camp of Namur.

Farther south within the trench of the Meuse River are the fortified towns of Dinant and Givet. The illustrations show with what precipitousness these walls rise. One would think that a defense could surely be made there, the narrow roadway running thru the trench, the upland held by the defenders, aided by the almost unscalable cliffs. The Sambre River cuts a similar trench thru crystalline rocks and joins with the Meuse at Namur. The topography was favorable; but in this case man was weak. It was not known when that fort was built that the modern offensive was stronger than the modern defensive. The forts could not stand against the modern guns, and later reliance was less upon forts than upon topography.

The Germans were advancing thru Belgium from the north and from the east, on the 22d day of August the battle opened from Namur and thru Charleroi to Mons. The eastern half of the line was held by the French. Near Mons is the little village of Binche and from there westward to Mons the British Army faced northward.

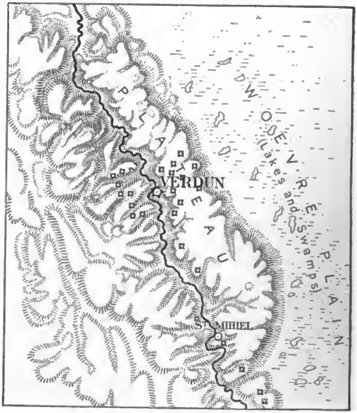
FLOODED FLOOR OF THE PETIT MORIN VALLEY, A TRIBUTARY OF THE MARNE WHICH PLAYED AN IMPORTANT RÔLE IN THE STRUGGLE

The French were behind the great river trenches. The British had no such natural defense, but lay behind the Condé canal and treated that as a river trench. Had the fort at Namur held—that was the crucial point—the British and the French might have been able to turn the enemy back. Von Kluck, von Buelow, and the Duke of Würtemberg, moving along different points in the line, began the attack almost simultaneously, beginning a little earlier at Namur, but the German siege guns reduced the fort within twenty-four hours, and von Hausen and von Würtemberg forced an entrance across the deep trench of the Meuse and broke the line. The line once broken, the French were in danger of having their center cut, so that the very trench they relied upon to defend them might have proved the trap into which they could have been driven. They commenced to retreat, and the next long battle was fought as a rear-guard action to defend a retreat of the French and British to some place where they could make a stand. The topography had favored them at the outset, but man had proved too strong for them, and they must retire to a place where once more Nature favored them. When the line was broken the British and French retired behind the fort of Maubeuge, to within the region where the River Oise joins the Seine, and made their next stand from the Oise to the Marne and upon the various tributaries of the Marne.



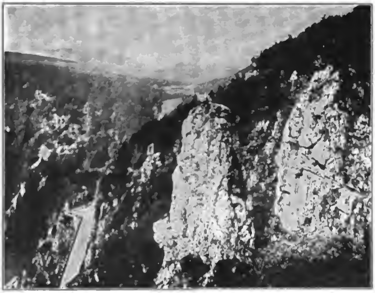
TRENCH OF THE AISNE RIVER

Let us see now what part the topography played in the fight at the Marne. After retreating from the Sambre and Meuse they made their first stand upon the Ourcq, which is a tributary to the Marne. There were several reasons why Paris could not easily be taken. The Seine River makes very large bends. There is a great ring of fortresses defending Paris, and the Germans would have to face the French and British armies, which lay upon the flank of any such advancing army and lay behind the great natural topographic defense of trenches these rivers have cut in the limestone upland. Consequently von Kluck turned southward and crossed the Marne. The world wondered why he did not take Paris, but this is the reason: He crossed the Marne and drove the French before him, leaving, while he did so, a thin screen of troops to defend his flank along the Ourcq. Just at that time Italy was one of the Triple Alliance. The Italian guns and Italian troops were massed along the border between France and Italy. The French had a great army there to defend themselves against the expected Italian attack. It is said that the German papers had published that Lyons had been taken by the advancing Italian troops. The Italian Ambassador at Paris, keeping himself in touch with events in Rome, had heard, at 2 o'clock in the morning, that Italy had decided to stay neutral. He woke the French Minister of War out of his bed and told him that the Italians were going to observe neutrality. The French sixth army was reinforced with troops from the Italian border, to be flung against that thin stream of troops. The French waited until the Ourcq, the great trench of the Marne, lay between them, and still waited until the Germans crossed and lined up here with the French center bent far back. Then the French made their assault from the west against this thin line of troops and flung them back against the trench of the Ourcq, where they were in danger of being destroyed. Had the French succeeded in crossing the Ourcq, von Kluck's army would have been cut off, but von Kluck commenced to retreat rapidly back and flung his troops against the French Army at that side. It was a difficult undertaking; rain had begun to fall, thus favoring the Allies, but he carried it out very successfully, leaving a thin screen of troops behind to hold the French and British back along the rivers. That held them longer than one likes to say. We may as well admit frankly that blunders were made. But at last the line broke and the



TERRAIN OF THE VERDUN DISTRICT

Allies crossed the Petit Marne and the Grand Marne, and the two armies faced each other on the trench of the Marne. Had that held, the Germans could have poured in such troops as would have destroyed the French sixth army, and their way would have been clear to Paris, but the Marne line did not hold, the Allies crossed it. Meantime, far to the eastward General Foch faced von Buelow across the Saint Goud Marsh. Germans believed the French could not attack, because the great swamp lay between, and in their eagerness to destroy the sixth army they had weakened their line. The French general saw a chance to break across that swamp. He broke thru it and cut the German center and rolled back that end of the army. One can hardly believe that that battle was actually won by the French, when one looks at the terrible history of the war since and sees what power the Germans have shown since that defeat.

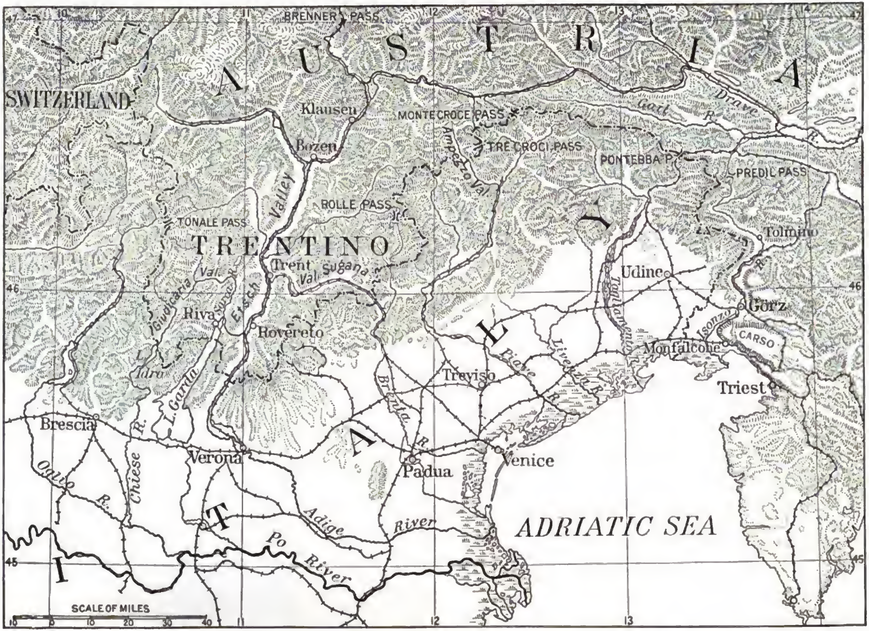

SCHLUCHT PASS ON CREST OF VOSGES MOUNTAINS, SHOWING CONTRAST BETWEEN STEEP EASTERN FACE (FOREGROUND) AND MORE GENTLE WESTERN SLOPE (BACKGROUND). IN LOWER LEFT-HAND CORNER IS THE CARRIAGE ROAD ASCENDING TO THE PASS

One of the illustrations shows the innermost of those cliffs, the one nearest Paris. It is not steep or rugged; it rises perhaps 300 feet above the broad, open plain which is developed on the soft rocks. Far in the distance one can see promontory after promontory, where the long cliff is dissected by the little rivers flowing thru it and out onto the plain, with the broad plain itself—the plain of Champagne across which was fought the famous battle of the Marne.

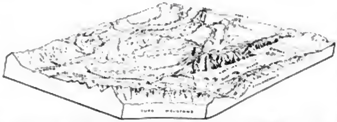
At Verdun, the Germans had to advance against one of these cliffs across the swampy lowland and fight their way up the cliff. They had three ways of attacking Verdun. At the north the Meuse winds its way out thru the upland to the plain of the Woevre, as shown on the map. At this gateway the Germans had entered the valley. They could have advanced from the north and they could have advanced across the plain from the east and have fought their way up that cliff. They could have broken thru at some favorable point at the south where the cliff lies lower and then come up the Meuse Valley from the south. They tried all three ways at once. They met with their least success where the topography was least favorable—advancing from the east. They failed to maintain a foothold on top of the cliff. To the south they broke thru and seized St. Mihiel, where their line makes a sharp salient.

The winding river leaves sharp spurs, jutting out on either side of it. The French fortified each one of those, and they have learned from the fall of Antwerp and a dozen other fortified places the terrible lesson that German guns can teach. The Germans demolished not, however, until the French had taken the guns out of the forts around Verdun, and placed them in secure emplacements behind those winding spurs. So when you heard of the Germans taking the Fort of Douaumont, above Verdun, you did not hear of them really capturing a fort like the fort of Maubeuge or of Liége, but simply of their taking the empty shell of the fort. The French were unwilling to give it to them, not because they wanted the fort, but because of the topography that the fort was placed upon. The guns were placed on these ridges, and if the Germans captured one they must fight upon it and fight their way up and take the next, and there lies cliff after cliff of that kind. A railroad that supplied Verdun runs thru the valley across the south end of the sketch, then across a low divide into another stream valley and out toward Paris. The same railroad passes eastward thru another little valley and thru a tunnel and across the Woevre

GUNTHERSTAL, SHOWING TYPICAL TOPOGRAPHY OF THE LOWER COURSES OF VALLEYS HEADING AGAINST THE STEEP SCARPS OF THE VOSGES AND BLACK FOREST MOUNTAINS



THE ITALIAN THEATER OF WAR, SHOWING THE PRINCIPAL MOUNTAIN AND PLATEAU BARRIERS, RIVER TRENCHES AND MARSHES, AFFECTING THE ITALIAN CAMPAIGNS toward Metz. That was the straightest route to Paris, and the capture of that railroad line—not the railroad, because that would be destroyed—was one of the main objectives of the attack upon Verdun. There was another reason, tho. Just at the time that Verdun was attacked most seriously, in February, 1916, the Russans had been beating the Austrians; Lemberg had fallen, and the Germans in the west had been without a victory for a long time. There was every political reason for winning a victory. There were four great fortified camps that the French relied upon, one of which was Verdun. None of them had fallen, and so Verdun must fall. For all these reasons the attack was made, and the Germans hoped to win by surprise.

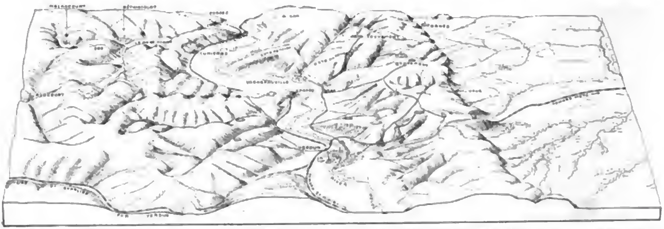

DIAGRAMMATIC VIEW OF THE BELFORT GATEWAY INTO SOUTHERN FRANCE. THE RUMORS CONCERNING THE INVASION OF SWITZERLAND HAVE REFERENCE TO THE POSSIBLE USE BY GERMANY OF THE PARALLEL VALLEYS OF THE JURA MOUNTAINS AND A DESCENT THRU THE DOUBS VALLEY TO THE REAR OF BELFORT

The Germans commenced their attack on the isolated height east of the Meuse, and pushed the French back to the line thru Côte de Poivre, Louvemont, and Douaumont. They had come down the valley and began to deploy outward across the cliff and began to take it. They succeeded in taking Forges and Regneville and the small valley westward to Bethincourt and Malancourt. South from that line is a slope leading up to a high, steep ridge, and that ridge overlooks the river. At the foot of the ridge on the river side is a little town called Cumières, and directly south of Bethincourt is a hill called Le Mort Homme (Dead Man Hill), west of which is 304-Meter Hill. The Germans advanced thru the Forges Valley from Regneville and beyond, then, turning southward, faced the French. You know the story of that fight; the hill is not high or steep, but slopes gently, leading down toward the assailants. As soon as the Germans came out from cover they were simply annihilated. It was not the forts but the favorable topography that made that defense impregnable, but along the line of the river the topography favored the Germans; they broke thru and outflanked the French, but still they could not fight their way to the town.

Italian Official Photograph

LINE OF TRENCHES ON THE CARSO FRONT

By the end of July the Germans had attained their fullest measure of success. They had by desperate fighting won Fort Douaumont. South of the fort is the little branching valley of Vaux. They took that, were expelled from it, took it again, and were expelled. The third time they gained the village and the fort of Vaux on the hill south of the town. From the Meuse River



Bird's-eye drawing of Verdun. To the right (east) is the Woevre lowland, fronted by the cliff of limestone. From February 25, when the first rush was checked, to March 9, the struggle centered about Côte du Poivre and Douaumont: From the isolated hill northeast of Ornes, the Kaiser watched for the fall of Douaumont. But the French right rested on the cliff, and their left was protected by the guns on the Charny and Cumières spurs. It was to break thru this left flank that the battle in succeeding weeks shifted to the Forges Brook that runs thru Bethincourt. For a time the Germans gained Douaumont and Vaux, but were expelled in December, 1916

across to the cliff lies a country branched with many of these little lateral valleys. In fighting their way across these deep gorges the Germans went simply from one death-trap into another.

Then came the second battle of Verdun—the counter-offensive of the French. Leaving the German line unchallenged except where their topographic positions made them dangerous to the continued defense of Verdun, the French took great care to expel the enemy from the portion of the ridge they held at the Côte de Poivre. From the cliff edge at Douaumont they have driven the Germans out onto the plain where the line now lies.

Now remains the plain of Belgium, and the reason can be seen why Belgium was invaded. The plain is richly cultivated and supports a dense population. It is even lower and flatter than northern France, and the lower parts of the rivers, as well as the sea-coast, have to be dyked to keep out the sea. The groundwater is so near the surface that where a trench is dug, the soldiers stand in water. The least little ridge is of strategic importance not only because of its height, but because one can have dry trenches there. When need arose, the Allies turned their great guns upon the sea-gates and dykes, and flooded the country, thus effectively checking the German advance in that region.

As to the Italian front: The Alps Mountains rise very abruptly out of the plain; the cliffs are a thousand feet high, up which roads have to twist and wind back and forth, as in the other similar regions in France. Such cliffs abut sharply upon the plain. These mountains are the ruggedest, sheerest mountains you can imagine. Few of our American mountains are so rugged as the Alps. The valley floors come down to within a few hundred feet of sea-level. In some places the valley is six hundred feet above sea-level, the heights on either side going up to eight thousand feet, so that there are seven thousand feet of almost sheer declivity. The rivers carry great amounts of sediment, which they fling down upon the plain, so they have built a great sloping land, richly fertile, made of rock-waste which they carry down thru the mountains. In the past glaciers of ice flowed thru every one of these valleys clear to the plain and built, in places, masses of mud and earth enclosing lakes which are held in between the valley walls and the material that the glacier heaped upon the land. Such is Lago di Garda, one of the most beautiful of the Italian lakes.

Most of this region is inhabited by Italians who speak a dialect of Italian—the Ladin dialect—and Italian colonists. It was not national aspirations that led the Italians to fight on the Allies' side in this war. A pretty bad picture was given by the newspapers before Italy went into the war. We saw her bargaining and looking to one side and then the other. What really happened was this: In 1859, Austria held Piedmont and Venetia. When these were restored to Italy the new boundary line was especially favorable, not to Italy, but to Austria. Running over the lower foothills about the Adige Valley, it rises toward the Swiss frontier, crossing Mount Adamello and the Tonale pass thousands of feet above sea-level. The Austrians held the dominating heights on every side, the Italians held the foothills. That frontier is a threat to all northern Italy, and the establishment of that frontier seemed a promise to Austria that one day she would win back what the Italians had taken from her of Italian territory. It was a strategic and a topographic and a racial victory that the Italians looked forward to, to

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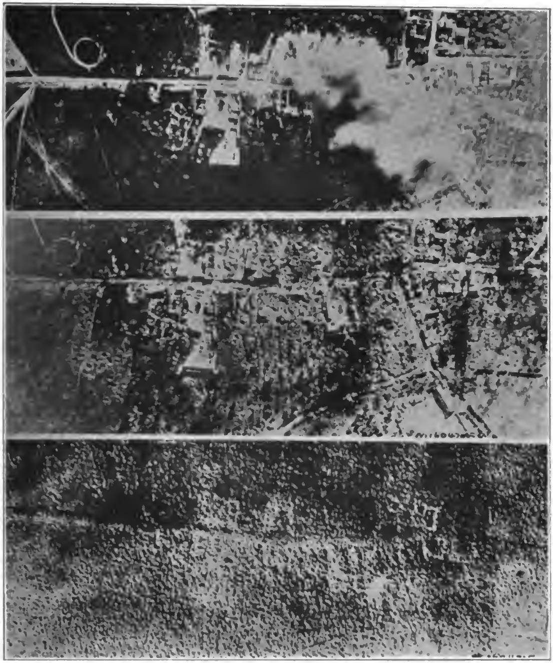
MOUNT PASUBIO LIES BETWEEN THE ASIAGO PLATEAU AND THE ADIGE VALLEY. THE AUSTRO-ITALIAN BOUNDARY PASSES OVER ITS SOUTHEASTERN FLANK. IT DOMINATES THE LOWER ITALIAN HILLS TO THE SOUTH



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Three aeroplane photographs of a French village near Peronne, showing how an effective bombardment utterly obliterates the place attacked. The top photograph shows the village as it looked in July, 1916, during the bombardment. The center photograph shows the condition of the village at the end of July, after it had undergone bombardment by cannon for several weeks. The bottom photo shows the village, nothing left but a mass of ruins, in August, when the guns had finished their work remove the threat that Austria made against Italy in merely holding that line. I want to make that clear, for the Italians have been very much misunderstood, and the picture of them as a group of hungry land bargainers, with national aspirations, playing politics, with their loyalty to this side or that, is a picture that is not correct.

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THIS PHOTOGRAPH SHOWS AN ENGINEER'S DEVICE FOR OVERCOMING THE TOPOGRAPHIC BARRIER OF THE ALPINE VALLEY

In making that attack they had the choice of moving eastward across the river Isonzo against the plateau and the city of Goritza—a difficult route; they had to leave in their rear a series of rivers that crossed their path. Or, on the other hand, they might move against the Adige Valley and fight their way to the mountains. The rivers favored them, leading northward from the Italian plain, but in the past there were glaciers in the northern end of all these valleys, so that at the northern end the ice had torn out the rocks to unscalable heights. To climb up on to the Asiago plateau the railroad has to wind up and up the cliff to the summit, which is a comparatively open country and has good roads. There are cross-trenches, the valley of the Adiges tributaries, and these cross-trenches favored the Austrians, who could deliver troops thru them.

Great mountains do not favor the defense, but the assailant who can fight unseen, whose victim can maintain only a few troops at any given point. The enemy being unseen, the defender cannot concentrate until the blow falls. Too often that is too late.

The Austrians on the heights across the Isonzo River could fire clear across that river to the Italians on the west side, so that they could not even approach the river. They could not take the heights until they crossed the river, and they could not cross the river until they took the heights. They made a crossing finally by means of tunnels, one of the most wonderful engineering feats ever put thru in war time. Once they broke thru this barrier they made a wonderful success in that region for a time.

NOTE.—Major Douglas W. Johnson, for reasons of military duty was unable to present the above paper, but sent as his substitute Mr. Frederick K. Morris. Major Johnson planned his paper upon his book, "Topography and Strategy in the War" (Henry Holt & Co., New York), and Mr. Morris adhered closely to that plan. The maps and diagrams—taken from Major Johnson's book, with one exception—were originally prepared by the American Geographical Society, and appeared in the *Geographical Review*. Permission for reproduction in the JOURNAL has been granted by Dr. Isaiah Bowman, Director of the American Geographical Society. The photographs were in part made by Major Johnson, and in part came from other sources and are reprinted from his book. The photographs furnished by Mr. Morris are from Underwood and Underwood, and two drawings were made by Mr. Morris.

"MY EXPERIENCES AT THE FRONT"*

By CORPORAL FRANK STREET

STRATHCONA LIGHT HORSE, CANADIAN ARMY

FOR three long years and a half we have stood before the German. He has had everything on his side; the preparation of forty years, for he has prepared ever since Frederick the Great stood on the Prussian throne and defied Sweden. Do not be pessimistic as to the outcome. He failed to crush us when we had nothing; how can he smash us now? No! Not in a thousand years!

After five or six days' fighting our line has retired. Mind you, there is an object in retiring in this case, and there is always an object in our retiring. For example, take the battle of the Marne. At that battle, for every inch of ground we retreated we set a price upon every square inch of that territory, and before the Germans put one foot on it they pay the price or they do not get it. In this case our price has been paid in full, and consequently the Germans have recovered a country that, when they retreated from it, they had devastated beyond description. What does it amount to? It is not territory in this war. It means this: that the people here have got to get behind us. We want the moral backing, and if we have that we have all that a country can give, because that means that every man, every woman, and every child in this country will stand behind us.

Now a word as to myself. I was in the Yukon prior to this war. When I came down it was 250 miles from the nearest railroad station. I was in the "pousse-cafe" country, as they call it up there, and arrived at a place called Grand Prairie. It is exactly 250 miles from Edmonton, 100 miles west of Edson, in Alberta. That was on the 26th of July, 1914. We had telegraph connection there, and word came thru that the war in Europe had started. I was born in Canada and brought up in the United States. I wanted to fight in this war for one thing, and one thing only. I was living in Canada, and a country that is good enough to live in is good enough to fight for, and die for, if necessary! That meant that I had to travel 250 miles, and I made that trip in eight days. It was a good breaking-in, for it is a hard, long trail up there, and on the 12th of August, 1914, I enlisted in the cavalry. I went across with the first Canadian contingent. We have a designation so that you can always recognize a first contingent man, and that is a designation of color, worn upon the shoulder strap. It means that the man who wears it was one of the first contingent that left Canada in October—the first of October, 1914. We landed in England six weeks after the outbreak of the war and were put on Salisbury Plains, the last place that God made and He forgot to finish it. In fact, we used to say, "If this is England, give it to the Germans. It isn't worth fighting for." But it is. Everything that those little isles contain is worth fighting for. Why? Because they have stood between us and the German brute!

That was our feeling regarding England. The story came back here that insidious German propaganda—they told you right before we ever got the first dose of gas, at the second battle of Ypres, as soon as the first Canadian contingent came here, they came into the States and they issued the propaganda—said that Great Britain sacrificed us and saved their own. I want to tell you something. They never sent us where they did not go themselves. For every Canadian that lies over there there are ten Englishmen, and I am not counting Scotchmen, Irishmen, and Welshmen. I am giving credit where credit is due.

In February we went to France, and we landed at St. Valery, and the first thing they did to us was to take off the top of our hair. Sometimes they have enough barbers' clippers to go thru. In this case they did not have enough. They used horse shears. The doctors give you a good reason. They tell you you are likely to get a wound in the head. Our opinion is different. After you get up the line you become acquainted with those little companions that stick closer than any German ever stuck.

Another thing they introduced us to was a pick and shovel. It was a case of dig, dig all the time. Why? Because we had at that period one machine gun. At the Marne we had only two machine guns at the outside for every 1300 men. We had no hand grenades, no bombs of any description. The biggest gun we had at the second battle of Ypres was a 4.7. The Germans had everything, from a pom-pom to a 17-inch. They brought into this war the most brutal things the human mind could conceive of, to crush the world and bring into it—bring everywhere—German "kultur." And then he says God is on his side. Are we on God's side? We know it, because we would not have stopped them; human nature did not stop the Germans alone. For instance, take the 22d day of April, when that gas first came over. I was in the infantry. So far as cavalry was concerned, it is a misnomer calling us cavalry, because all the cavalry work we did there was on these legs—walk on them—and when we got there it was a case of go up and live in the trenches with the rats for a while. No horses. Dismounted, we went up to the Royal Dragoons, but we had to dismount and go in the trenches again.

The story of the Somme was a pretty dear one for the Germans.

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* Presented at joint meeting of Engineers' Club and American Society of Mechanical Engineers at Witherspoon Hall, March 27, 1918.

Another thing, and that is, that no matter how we feel—no matter how hard things have gone—the Germans have never been able to wipe that smile off our faces. We can always laugh. For instance, up in the front-line trenches you will see a fellow there and a whiz-bang goes over his head. He ducks and another one comes along and he ducks again. One of the fellows asks, "What are you ducking?" and he says, "Gee whiz, if I don't duck this one I won't get a chance at the next one."

Those communication trenches at that time in the beginning we made ourselves. We used to go up behind the front line, and every movement you make must be done at night, in the dark, and you cannot see your finger in front of your face. Going along you have a fellow about five feet in front of you and have a shovel attached to you, or perhaps you have a shovel and the other fellow has a pick. All of a sudden a 17-inch shell whizzes by you and when it lands it tears a hole in the ground thirty feet in circumference and twenty feet deep. These shells have killed men fifty feet away from them and the man has not had a mark on him. And when they come by your heart comes up in your throat and you say, "That's all right; it's gone." You think you have not eaten for a week. It always reminds me of the story of the Irishman who always likes a scrap.

One day, suddenly, at the Somme, after five days of roar and bombardment, the guns stopped and we went over. Before it was, "Over you go and the best of luck." No gun behind, and you look around to see where the next one was coming from. This fellow ran up and down the parapet; nothing happened, and he yells, "Three cheers for the Kaiser!" Somebody said, "What are you doing, Pat? Are you mad?" And he says, "Well, he started it, didn't he?" It reminds me of the fellow that was just going up over the top; he just got to the parapet and something bit him on the leg. He reached down to his leg and as he did so a shell missed his head, and he said, "Old boy, I cannot give you the Victory Cross, but, say, I'll give you better feed." And then people say there is no humor out in the front line. There is all kinds of it. Sometimes you will see a man sitting on the firing platform with a deck of cards—four of them in the daytime. You cannot do much in the daytime, anyhow. The shells are gaping over your head and you will play a game of cards. Maybe in the middle of it the game will be spoiled. There is not one second of the day that there is not some men "getting it" over there.

Go back now to the period when the Germans first released their gas. If you could only realize what that means to the civilized world; to think that any nation could sink to a depth lower than any savage race; could sink lower than any nation ever sank before in the world's history—you could realize to the full that this is not my fight, it is not your fight, it is our fight—every one of us! The gas came over in a yellowish-green cloud. The first troops that got it were the French troops. They gave ground and came back farther still. They passed all the four guns and came down the road. But it was too late; there was a gap four or five miles wide in the line. The Germans came on, but they hesitated a while, and that saved the day. There is no doubt of it. The results were frightful. To see men coming down the road, trying to get another breath of fresh air, scratching their faces, dying! It was a sight unspeakable, and the men that suffered first, and always suffers first in that case, is the man that is lying there wounded, because the wounded man, unable to get away, will crawl into a shell-hole or a dug-out, and this gas, being heavier than air, reaches him first and he dies, not even with a fighting chance! Murder! Unadulterated murder!

Then, again, we hear stories that we brought into use these other methods. There is not one thing, even down to the liquid fire, dum-dums, and explosive bullets. What does an explosive bullet do? It enters your arm at one place in a little pencil-hole wound and comes out at another, tearing the flesh to pieces. They even put glass in the shrapnel. That's the German method. In May, 1915, I myself took from a Bavarian a saw-toothed bayonet. They run it into a fellow, turn it, and pull it out, and leave you to guess the rest. That's the German nation. But that is nothing. The thing that made us swear that we will not quit until we drive them off the map were those awful atrocities the Germans have committed in Belgium and France and all those little people that they put their feet upon. That is what we are in this war for, and if we do not stop them there they will come here to your homes and commit in a worse way the same deeds they have committed in Europe.

For instance, I went into a hospital in London in November, 1914, before I ever saw France, and there I saw a Belgian boy, a little lad of about eight years old, minus his right hand. I was told by the doctor that the little fellow had lost his hand by a bayonet. A German had deliberately hacked it off at the wrist. The idea was that when the boy grew up to manhood he would not be able to defend his country.

Another case: A boy had a letter from his mother. He was in my section. He was sittnig outside on a biscuit tin. Coming up toward him, I saw he was sobbing, and it is pretty bad news when a soldier sobs. I asked him what was the matter. He did not answer me, but he handed me the letter and I read it. The letter told him that he was to take no German prisoner if he ever came into contact with any, because a girl he had gone to school with had come back and the center of her hand had been cut and the cords had been pulled out—this letter was from his own mother—and this girl will remain that way for the remainder of her life. I asked him if he thought it was correct, and he said, "One word in it is only sufficient. My mother doesn't lie." No mother on earth would write such a letter to her son if it were not the case.

We went to France. If we went into a French village, what did we see? Not those awful, unspeakable atrocities —it was the army of the original expeditionary force—but we saw the results of it. We would go into a place and find half a dozen children in that time minus their hands. We would see another case where a young girl was minus an arm up to the elbow. That is the German method; and in one case in particular, at a village called Givenchy, there is a little town near it, and in this village lived this girl and family—a mother and father, two younger brothers, and a sister. The Germans broke in that place. They took the father and ran him thru. That is nothing. They tied the mother to a door and violated that young girl in the presence of the mother, and stood those two brothers up and held a bayonet at them, and when that was done they murdered them. That is the German nation. No, we are not fighting the Kaiser! But every one, regardless of—whether man, woman, or child that stands behind the principle of Kaiserism—whether German, Austrian, Bulgarian, or Turk, it make no difference. The Turk is not half as bad as the German himself. And we have proof of that on the battlefield itself. For instance, at Festubert they took twenty-four of our men and stripped them stark naked off on the front-line trench. They kept them there over night, and this was on the 24th of May. At daybreak they drove them at the point of a bayonet and turned on them a machine gun and mowed them down. Is it any wonder that we took a revenge we were justified in?

There was another thing also the Germans did—the time they crucified those sailors at St. Eloi. Our watchword was, "There's many a slip betwixt the cup and the lip." The Germans we took prisoners had to be wounded, helpless men, because we were not collecting souvenirs.

What I have told you just shows the German character. But to go back and come down to that period in the front line when we stood up there with nothing in our hands, simply flesh and blood against iron and steel, and then at this crisis people stand back and say, "Will the line break?" No! It will not break! Not in a thousand years! Our line may bend, but it won't break. It cannot break, because if it did break you may just as well go out and look for six feet of ground somewhere, look into it, and pull it in after you.

At Givenchy, in June, 1915, we were fifteen yards from the German front line. I thought you might be interested in knowing how we got those trenches up. If you cannot imagine it, try it some night when you go home. Go into the back yard and get a pick and shovel and get a pillow-slip to make you think it is a sand-bag, and then dig a hole three feet six inches across the top, the same across the bottom and about three feet deep. See how long it will take you; see how soon you will get thru. We had to do that all the time, and the only time we could work was at night. With all that work going on it is surprising how small a portion of France you yourself individually occupy, but once you realize you are only a small thing you are all right. It takes some people a long time to realize that.

We were fifteen yards from the German front line at a place called Duck's Bill, and the Germans were throwing bombs at us. We had none, so we made some. We did not even have a bombing school behind the line at that period, and it was not until the end of June, 1915, that we established our first bombing school. After that each man went back for ten minutes' instruction, and he was supposed to be qualified at the end of that time. Some were and some were not. They were bombers just the same. However, we got up at the bombing line. We took these pound tins of jam. We would have apple and plum to-day, plum and apple to-morrow, and, by way of variety, apple and plum the next day. After eating the contents of a can we would save it, and then we would give it to a bombing school we were instructing. We would take bullets from cartridges, nails, little pieces of pebbles, and then would wrap them into the tin and put a five-second fuse in it and carry it up to the front line with us, and get into the front line and start tossing over a piece of beef—bull beef or anything at all. That is "fraternizing" with the enemy, yet at the same time it was with an object, and then Fritz wanted more. We would sing the "Wacht am Rhein," and at a given signal—one, two, three—throw over a bomb and yell, "Ah, Fritz, you have it amohg you!" But he always got sore. Aside from that, there is always a climax. After we had finished all this we would always sing, winding up with the "Wacht am Rhein," and that always started a fight. So the best thing was to keep quiet.

Another thing happened recently, and that probably has been brought home to you more than ever, and that is this long-range bombardment of Paris. It accomplishes nothing. It is almost as bad as getting over an open town and bombing it from 10,000 feet in the air. There is no military damage done—just simply slaughtering the women and children. People say, "Why don't we have reprisals?" I will tell you why. We bombard open towns only if we can hit the railway station. The reason we do not bombard open towns is this: We are better than the Germans ever thought of being. We do not have to dirty our hands. We do not have to commit murder. And we are not fighting women and children. We are going to win. We *must* win. We can win. But we cannot win if the people behind us fail, because it takes nine men to keep one in the front-line trenches; it takes approximately nine tons of shipping—one ton to get a man there and eight tons to keep him there; that is as near as it can be figured out. And when I say nine men I mean for every man that stands behind the men that are there it takes just nine men—the man on the lines of communication, the man on the transportation, in the shipyards, and in the munition factory.

Here is another thing: In Great Britain they said they had to have Zeppelin raids before England woke up. In ten days those little islands of Great Britain had 100,000 volunteers; in six weeks, 1,000,000; in twenty-one months of war, 5,000,000 volunteers before they put conscription into effect. I have to tell you this, and this is a fact: we have under arms to-day, so far as the British Empire is concerned, about 8,000,000 men. We are fight-

(Continued on Page 239)

"WIN THE WAR" CONVENTION

ONE of the most important and significant conventions held in any city of the country will meet in Philadelphia on Thursday and Friday, May 16 and 17. It will be important from the standpoint both of the individual and of the nation, in that it has to do with the course this country and the other great powers will take, at the close of the war, to secure and maintain a permanent peace.

The convention is entitled a "Win the War Convention," and it is to be held under the auspices of the League to Enforce Peace. The League was organized in Philadelphia, at Independence Hall, two years ago, under the presidency of Former President of the United States, William Howard Taft, who is still its chief executive.

Briefly, the object of the League is to have this country lead, or join in, a movement for a League of Nations binding the signatories to the following:

First: All justiciable questions arising between the signatory powers, not settled by negotiation, shall, subject to the limitations of treaties, be submitted to a judicial tribunal for hearing and judgment, both upon the merits and upon any issue as to its jurisdiction of the question.

Second: All other questions arising between the signatories and not settled by negotiation shall be submitted to a Council of Conciliation for hearing, consideration, and recommendation.

Third: The signatory powers shall jointly use forthwith their economic and military forces against any one of their number that goes to war, or commits acts of hostility, against another of the signatories, before any question arising shall be submitted as provided in the foregoing.

Fourth: Conferences between the signatory powers shall be held from time to time to formulate and codify rules of international law which, unless some signatory shall signify its dissent within a stated period, shall thereafter govern in the decisions of the Judicial Tribunal mentioned in Article One.

These objects of the League will be discussed at the two-days' meeting by some of the ablest speakers in the country. The meetings during the day will be held in Witherspoon Hall, and the big evening meeting of Thursday will be in the Academy of Music.

The first of the sessions will be held in Witherspoon Hall on Thursday morning, at ten o'clock, and it will be known as the "Keynote Session." The first speaker is George Wharton Pepper, of Philadelphia, chairman of the State Committee of Public Safety, and his subject will be, "A Struggle for World Freedom." Mr. Pepper will be followed by the president of the League, William Howard Taft, who will speak on "America Seeing It Thru." Three other important addresses will also be delivered at this meeting, by Edward A. Filene, Dr. A. Lawrence Lowell, president of Harvard University, and Stephen A. Wise. Their subjects respectively are: "The War and the Individual," "Safeguarding the Future," and "Battling for a New World."

At the afternoon session of Thursday the general subject will be "What We Are Fighting Against." This meeting will be devoted largely to Germany and the governmental elements of that power which have controlled for so long and which have precipitated the terrible disaster from which the whole world is now suffering.

The meeting will be opened by Richard Heath Dabney, who will discuss "Germany's Dream of Dominion," followed by W. Morgan Shuster, whose subject will be "An Efficiency Without Soul." John Spargo will be the next speaker and he will talk on "A 'Made in Germany' Socialism." Dr. Anna Howard Shaw will speak on "The Degradation of Childhood and Womanhood," and she will be followed by Charles B. Elliott on "German Exploitation of Backward Peoples." The session closes with an address by Robert McElroy, "Kultur: Its Attempt to Educate the World."

The big meeting of the convention will be held on Thursday evening in the Academy of Music. The general subject is "What Democracy Would Face if it Lost the Fight," and the unenviable position of the democracies of the world in case of a German victory will be clearly set forth by some of the leading students of sociology and of politics in its widest sense that the country possesses. Franklin H. Giddings will open the session with an address on "The Collapse of Civilization in the Next War," followed by Prof. Leo S. Rowe, who takes for his subject, "Armament and Taxation." Oscar S. Straus will discuss "A War Basis for Business and Labor," and then will come two of the best-known speakers who will be in attendance at the convention—Dr. Lyman Abbott, who will speak on "A Subordination of Democratic Freedom to a Prussian Discipline," and Charles Evans Hughes, former Governor of New York, whose subject will be "A Lawless World."

The first of the Friday sessions will be held at ten o'clock, at which the keynote will be "A Program of Constructive Patriotism." The speakers are Henry Van Dyke, Lyman P. Powell, Charles S. Medbury, and Charles S. Ward. Doctor Van Dyke will take as his subject, "Fighting for Peace," and he will be followed by Mr.

Powell, who will discuss "The Goal of Sacrifice and Service." Mr. Medbury talks upon "Mobilizing the Mind of America," and Mr. Ward closes the meeting with an address on "A Program of Action for the League."

In the afternoon there will be two simultaneous sessions, one at Witherspoon Hall, at which the general subject will be "A League of Nations—America's Responsibility and Duty." Dr. Talcott Williams, formerly of this city, and one of Philadelphia's most distinguished men, now in charge of the Pulitzer School of Journalism in New York City, will open the session with a paper on "A Monroe Doctrine for the World," to be followed by Herbert S. Houston, who speaks on "Commerce and the Mailed Fist." Mr. Houston will be succeeded by the Hon. John Sharp Williams, who will discuss "The Only Peace Worth Having," and the Rt. Rev. Thomas J. Shahan, who talks on "Shaping the World's Ideals." The meeting will close with an address, "A New Order of International Coöperation," by William English Walling.

Simultaneously with this meeting, there will be a conference of governors and former governors in Independence Hall. Attracted by the international importance of this convention, many of the governors of the principal states of the Union have accepted invitations to be present and participate. This meeting will be presided over by former governor of New York state, Charles Evans Hughes, and the address of welcome will be delivered by Governor Martin G. Brumbaugh, of Pennsylvania. A large number of former governors, in addition to those now in office, some of them of national reputation, will be present, and possible Gubernatorial action in furtherance of the League's plans will be discussed.

In the evening there will be an Allied War Dinner at seven o'clock in the Bellevue-Stratford Hotel. Mr. Taft will preside as toastmaster, and the speakers will be Lord Reading for Great Britain, Ambassador Jusserand for France, Viscount Ishii for Japan, General Guglielnotti for Italy, and Secretary of the Navy Daniels, Judge Alton B. Parker, and Nicholas Murray Butler for the United States. This dinner will close the convention.

Philadelphia can well give its hearty support to this movement, which has so much behind it for the welfare of the world. It aims simply to make the world a better place to live in after the war, and to render impossible a repetition of the calamity which has drenched civilization in blood.

"MY EXPERIENCES AT THE FRONT"

(Continued from Page 237)

ing this war in many places. We are fighting it in India; we are fighting it in Africa; we are fighting it in Italy; we are fighting it in Salonika; we are fighting it in a dozen different places, and it was only a short whlie ago that the actual frontage was thirty-six—thirty-six actual fronts we were carrying this war on—and that takes men. But do not think that we are the only ones. We are not. When this war is over Great Britain cannot say she won the war. France cannot say that she won the war, nor can Italy, nor America. The only way to look at it is that *we* won the war, all combined, because there is not one nation on the face of this earth that had one ghost of a chance against Germany alone, because it had come down to the system of organizing every last resource in its possession. The reason there is such divergence of opinion is that we are a free people—the French, Italians, English, and Americans are not going to allow anyone to dictate to them in politics. Germany has her people under her thumb if they do not live up to the mark. For instance, take Belgium. The people were driven to work at the point of the bayonet. The women have been forced to work in the fields. They have done it with their own people; we know that, and then people say, "How is it that the Germans can throw up a mass of men on the front?" That is what they are depending upon all the time—their man-power.

You can rest assured that this is practically the last time the Germans will be on the offensive. I say that because we have not used one of our reserves on this front. In this scrap we are waiting, and the same thing will occur here that occurred at Ypres in 1915; the same thing that occurred at the third battle of Ypres in 1916, only our line was again broken—and it was broken then, not bent. The Prussian colonel came behind the line, and out of 12,000 men that went in, there were only 2000 left. He came back and when he saw the results he cried like a child and said, "My God! Had we known it!" That is why they are not going to get thru now, because Germany cannot keep up this offensive and pay the price we demand. And yet you hear these people who stand behind us—for instance, I am going to name a man over in Britain—Ramsay MacDarnold—a pacifist who wanted to go to Russia. The English firemen and sailors said they would not take him unless he signed a document to this effect: "I believe in the just demands of the British Labor Party, that Germany shall pay for and make reparations for the wrongs and murders committed upon the sailors and their families in this war." And when he signed it they took him to Russia, and they would not bring those men across here for the same reason.

We have not only got to fight this war over there. We have got to see that the people who are over yonder get a square deal—clothing, food, ammunitions, and everything that they need; for, after all, if a man is willing to go and make sacrifices, surely he is worth standing up for, and remember he is protecting you, he is protecting your wife, her honor, your sister's and your mother's, maybe. But there is one sure thing: he is protecting his government, his principles, and democracy for all time, because we are going to win!

THE MUCH-ABUSED TERM "MASS" IN ENGINEERING CALCULATIONS

By CARL HERING

DISCUSSION BY JOHN C. TRAUTWINE, JR.

IN the December JOURNAL, Dr. Carl Hering, discussing "mass" formulas, says:

> "The engineer, . . . when he expresses the masses in some of these formulæ in terms of the usual well-known units of mass, . . . sometimes finds that he gets totally wrong results, about 10, 30, or 1000 times too great."

But happily, as Dr. Hering further says:

> "There is really no reason why there should be any confusion at all," and "the confusion . . . lies entirely in the *incorrect interpretation of the results*."

No one need get "totally wrong results" from the accepted formulæ, *provided only that he will use the proper units and will respect the perfectly rational rules of the game.*

In any system, the force unit is that force which gives *unit acceleration* to the unit of mass.

In the C.G.S. (centimetre-gram-second) system, that unit acceleration is 1 cm./sec./sec.; and the unit force, which gives this unit acceleration to unit mass (1 gram), is 1 dyne.

In the same C.G.S. system, the *weight* of a gram of mass is a force which gives that same mass (1 gram) 981 times the unit acceleration. Therefore, in the C.G.S. system, the weight of a gram of mass is 981 dynes.

But "the man in the street" loosely says that a ship *measures* so many *tons*, misapplying the name ("ton") of a *weight* unit to a *volume* unit; and it is a very common practice, even among scientists, to say:

> "a gram of mass *weighs* a *gram*!"

We thereby similarly misapply the name ("gram") of a *mass* unit to a *force* unit; and, moreover, we mix up the C.G.S. system and another system in a single expression, substituting the miscalled "gram" (of *force!*) for the equivalent 981 dynes of the C.G.S. system, without making a necessary change in one of the other two factors, m and g.

Hence, of course, results confusion worse confounded; but, if we think it advisable thus to abandon the C.G.S. system, with its dyne and its centimetre, and to adopt another system, having a force unit = 981 dynes, we may do so without going wrong, *provided, of course,* (1) that we make any necessary and corresponding changes in the values of our *other* units inseparably bound up with the force unit; and (2) that we do not court confusion by applying (for instance) the name of a *mass* unit to a *force* unit.

In order to avoid hopeless and wholly unnecessary ambiguity, we will call this new force unit (= 981 dynes) one "gryne," instead of one "gram."

As we have seen, the gryne, being 981 dynes, gives to unit mass (1 gram) an acceleration of 981 times the unit acceleration (1cm./sec./sec.) of the C.G.S. system; and (if we are to retain the gram as our mass unit) this *greater* acceleration (981 cm./sec./sec.) must now be called "unity," because our adopted *unit* force (such as the gryne) must give *unit* acceleration to our adopted unit mass.

In other words, we must now adopt a new *length* unit, = 981 centimetres = 32.2 feet. We will coin the name "metrog" for this new length unit, devised in order that (if we please) we may use the gryne without inviting new confusion.

Adopting, as a force unit, the "gram," (which I call the gryne), one thus abandons the "C.G.S." (*centimetre*-gram-second) system, and passes over to a new "M.G.S." (*metrog*-gram-second) system.

The two systems are illustrated side-by-side in the following tabulation of Doctor Hering's cited case of a mass of 3 grams, moving with a velocity of 4 cm./sec.; where, as Doctor Hering shows, 24 dyne-centimetres of work have been exchanged for their equivalent in kinetic energy.

Following Doctor Hering, the writer assumes that, in each case, the given velocity has been generated in one second; so that velocity, v, = acceleration, a.

In the upper part of this table, using the formula, $m = W/g$, we deduce the mass, m, of the body, from its weight, W. In the lower part we follow Doctor Hering in deducing the amount of work exchanged for kinetic energy in generating the given velocity.

System	C. G. S.	M. G. S.
Weight, W	2943 dynes	3 grynes
Gravity accel. g	981 cm./sec./sec.	1 metrog/sec./sec.
Mass, $m = W/g$	3 grams	3 grams
Time, t	1 second	1 second
Acceleration, a	4 cm./sec./sec.	$\frac{4}{981}$ metrog/sec./sec.
Velocity, $v = t\,a = a$	4 cm./sec.	$\frac{4}{981}$ metrog/sec.
Distance, $d = vt/2 = v/2$	2 cm.	$\frac{2}{981}$ metrog
Force, $f = m\,a$	12 dynes	$\frac{12}{981}$ gryne
Work, $e = f\,d$	24 dyne-cms.	$\frac{24}{981^2}$ gryne-metrogs

Doctor Hering refers to the gravity acceleration, g, as "an unwelcome intruder," and suggests that it would be better to "cut it out." Incidentally, the M.G.S. system has this advantage, that it *does* "cut out" g by making it unity; and one is tempted to wish that the founders of the metric system might have found it practicable to establish that system upon a length unit = twice the distance traversed by a falling body during the first second of its fall. We should then have had $g = 1$, and the present discussion need not have been written.

If, even with the savant-made metric system, scientists acquiesce in the popular monstrosity:

"a gram of mass *weighs* a *gram*,"

we cannot wonder that they say, also, in our archaic English units:

"a lb.* of mass *weighs* a *pound* *";

for this had been the universal practice for centuries before scientists found it convenient, for their purposes, to say, instead:

"a lb.* of mass *weighs 32.2 poundals*,"

a statement without meaning for the man in the street.

In working out Doctor Hering's example, above, we chose to keep our *mass* unit (the gram) *constant*, and made the necessary adjustment (for the new *force* unit, the gryne, = 981 dynes) in the *acceleration* unit, raising this to 981 times 1 cm./sec./sec.

But, in English measures, when the "pound" * (= 32.2 poundals) is adopted as force unit, instead of the poundal itself, then, instead of raising the *acceleration* unit, as before, it is customary to leave *it* constant, at 1 ft./sec./sec., and to make the necessary adjustment in the *mass* unit, raising *this* from 1 lb.* to 1 "matt," = 32.2 lbs.*

We thus have two pairs of systems of units, comparing as follows:

System	Force unit	Mass unit	Acceleration unit
A 1. Centimeter-gram-sec.	1 dyne	1 gram	1 cm./sec./sec.
A 2. Metrog-gram-second	1 gryne = 981 dynes	1 gram	1 metrog/sec./sec. = 981 cm./sec./sec.
B 1. Foot-lb.*-second	1 poundal	1 lb.*	1 ft./sec./sec.
B 2. Foot-matt-second	1 pound * = 32.2 poundals	1 matt = 32.2 lbs.*	1 ft./sec./sec.

We get into trouble (as we deserve) only when we do violence to one of these two pairs of systems, by unwarrantedly "crossing" the units of its two members; as when we use the gryne (the miscalled "gram") of force, of A 2, in improper connection with the gram and the cm./sec./sec. of A 1; or when we use the "pound" * force of B 2 (= 32.2 poundals) in connection with the lb.* mass and the 1 ft./sec./sec. acceleration of B 1.

Of course, the punishment fits the crime—or, rather (to use language more nearly worthy of engineers), the consequence fits the blunder.

John C. Trautwine, Jr.

Reply by Carl Hering

Instead of simplifying things, Mr. Trautwine's proposed complicated and involved new system and new units make the already existing confusion far worse. Can there be anything simpler and less confusing than to say that in the usual formula $\frac{1}{2}mv^2$ one can correctly substitute the mass *in pounds* and the velocity in feet per second, and that the answer will then necessarily be in the corresponding existing unit *foot-poundals*, which are easily reduced to *foot-pounds* by dividing by g? Or, expressed still more briefly (tho then lacking the derivational feature) by $0.01554\ mv^2$ = foot-pounds, in which m is in pounds?

It is always objectionable to confuse and burden the mind by creating new units and names when the existing ones are in every way ample. It is for this very reason that this article was written (see The Journal, December, 1917, page 571), opposing that unnecessary, confusing, second and unnamed set of units of mass, w/g, used in so many text-books. In opposing unnecessary additional units most engineers will agree heartily with me. Exceptional cases sometimes arise (one of which was referred to in the above article) in which a new unit is very desirable and even necessary, and in that case it should, of course, be named; sometimes this is justified even when a sister unit already exists, as in that great time-saving unit of cross-section, the circular inch, even tho the square inch existed before. But Mr. Trautwine's proposed new units are quite unnecessary, as we can do all we need to do quite well without them.

To state that terms are "misapplied" when the term gram (or pound) at one time is applied to a unit of mass and at another time to a unit of force (weight), is in direct opposition to the technical community, to general and good practice, to the Bureau of Standards, to the Government, and even to the phraseology used in the legal definitions of the standards or their interpretation.

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* Seeking to mitigate the confusion inseparable from the misuse of the word, "pound" to mean sometimes a *force* and sometimes a *mass*, we here make the arbitrary distinction of *spelling out* the word, "pound," for the *force* unit of system B 2, and *abbreviating* this to "lb." for the *mass* unit of system B 1; "1 *pound*" being the *force* (= 32.2 poundals), which gives 32.2 ft./sec./sec. acceleration to "1 *lb.*" of *mass*.

Legally what we call our weights are, for good reasons, defined as masses; a pound is therefore correctly a *unit of mass;* but all engineers know that a foot-pound is a well-recognized and very frequently used unit of energy, and that the term "pound" in this unit is, of course, a *unit of force* and *not of mass;* a foot-pound is the work done by a pound of *force* acting thru a foot, as every one knows; a pound of force is therefore a well-recognized unit of force, even far better known and far more frequently used than its sister unit, the poundal. Both uses of the term pound therefore being common, accepted, well-justified in practice, and indisputably correct, there is no "misapplication" in using the unit pound sometimes as a mass and sometimes as a force. It is unfortunate, but it is not incorrect, and is general practice.

There are therefore in good usage two units of force connected with the pound; the more usual one is the pound of force (the weight), as in the foot-pound, and the less usual one the poundal, based on the acceleration as defined in the article; it is quite correct to use either, hence we use the one best adapted to any particular problem, or necessarily resulting from some formulæ.

This does not involve any "mixing up" of the C.G.S. and other systems, or "thus abandoning" this extremely useful system, which no physicist would dream of doing until a better one has been devised and universally accepted. The C.G.S. system is based on the centimeter, the gram (mass), and the second as the fundamental units, as its name specifies. When all engineers speak of a "foot-pound" as meaning a pound of force acting thru a distance of a foot, we are in no way "mixing up" anything. Even in the C.G.S. system the precisely analogous unit gram-centimeter is used, is correct, and is justified (barring the variations of g), notwithstanding the existence there, too, of the corresponding sister unit, the more fundamental dyne-centimeter or erg; one can and does use either without "misapplication" or "mixing up." In using the gram, pound, or kilogram as units of forces equal to their weights the C.G.S. system is not being "abandoned." All these units have been very fully explained in my book of conversion tables, and no error or inconsistency in reference to them has ever been pointed out, altho the tables have been published for many years.

It is not only "common practice" but also almost universal usage, and is considered perfectly correct, to say that "a gram of mass weighs a gram" (barring, of course, the variations of g); much confusion would arise if this were now forbidden! It would strike at the very root of an enormous number of engineering calculations, as our favorite energy-units, foot-pounds, and kilogram-meters would then have to be abolished.

Mr. Trautwine's definition of the unit of force is based *only* on acceleration and mass: force = mass × accelertion. As a matter of fact, in probably 999 cases out of 1000 in engineering calculations the practical unit of force—namely, the pound or kilogram—is based on the other derivative formula: force × distance = energy, a much simpler formula, in which neither mass nor acceleration is a factor. Both are, of course, correct, and in any complete system either or both can be used; it is merely a matter of convenience. In the C.G.S. system the former is more generally used; in our everyday system, the latter. The only objection to using the pound as a unit of force is that it is not quite as constant, owing to the variation of gravity; but in almost all engineering calculations this is too small a factor to be considered.

I am not in the slightest degree responsible for the third column of Mr. Trautwine's first table, the "M.G.S." system, which he alleges I had "passed over to," as by reference to my original article no such expressions can be found, or are implied.

In using the simple method of calculation recommended it is *not* "necessary" to make "corresponding changes in the values of our *other* units," such, for instance, as changing our unit of length to one of 32.2 feet. My article showed how all the common engineering calculations of this kind could be made correctly and simply, with nothing more than our common, existing, well-established units.

No error in my article has been pointed out. One might have been, however, as the "unnamed" unit, p. 573, the top of the second column, has been named, a fact which had slipped my mind at the time. It is the unit joule or watt-second, well known at least to electrical engineers, tho really a purely mechanical unit of energy, as its name implies, and convertible into kilowatt-seconds (1000 joules) by a mere shifting of the decimal point. It was correct, however, to say that the corresponding force unit (a rather important one) has not yet been named.

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LEWIS H. KENNEY, CHAIRMAN

MR. JOHN D. GILL

REGULAR MEETING

At the Club House, Tuesday, May 21, 1918, 8.15 P.M.

The paper of the evening will be presented by **Mr. John D. Gill**, Member, on

"War Status of Gasoline and Fuel Oil"

Mr. Gill will discuss briefly the composition and more important properties of gasoline and fuel oil; the present rate of production and consumption and the outlook for the war period; the substitutes used abroad; the utilization of these products in the vigorous prosecution of the war in the aeroplane, the armored tank, naval and merchant vessels and in special processes in the arts; the relation between the gasoline motor-truck and emergency war transportation; the possibilities of pipe lines as a freight congestion preventive, and the fuel oil and man power conservation.

The paper will be illustrated with lantern slides.

The annual presidential address by **Major John A. Vogleson, U. S. N. A.,** will be presented.

PRELIMINARY ANNOUNCEMENT

Tuesday, June 18, 1918, 8.15 P.M., **at the Club House,** The Junior Prize paper will be presented by the author.

NOTICE

Subject to the following rules, cards, extending the privileges of the Ladies' Dining-Room, will be issued, upon request of a member, to any of the ladies of his immediate household; provided their names are entered by the member in a book to be kept for that purpose in the office.

Upon request, these cards must be shown to the attendant at the door.

The Ladies' Dining-Room is for the use of the holders of such cards, who may be accompanied by other ladies; and for members or holders of thirty-day cards, when accompanied by ladies.

Ladies making use of the dining-room must sign restaurant orders with their own name and the member's name at whose request their cards were issued.

All orders served in this department must be charged to the member's account, as no money will be received.

Wines and liquors will not be served to ladies unless accompanied by members.

All cards are subject to recall by the House Committee at any time.

SCHEDULE OF MEETINGS
THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES
MAY, 1918

Wednesday,	**May 1, 1918**	Technology Club of Philadelphia "Engineering Problems Met and Overcome at Hog Island"	**Engineers' Club**	8.15 P.M.
Thursday,	**May 2, 1918**	Worcester Tech Club "Elements of Accounting" **A. W. Baldwin**	**Engineers' Club**	8.15 P.M.
Thursday,	**May 9, 1918**	American Society of Heating and Ventilating Engineers "Spontaneous Combustion" **Dr. M. W. Franklin**	**Engineers' Club**	8.15 P.M.
Monday,	**May 13, 1918**	American Institute of Electrical Engineers "The Big Creek Plant of the Southern California Edison Company" **Mr. J. H. Anderton**	**Engineers' Club**	8.15 P.M.
Friday,	**May 17, 1918**	Illuminating Engineering Society **Joint Meeting With Philadelphia Safety Council** "The Relation of Light to Health" **Dr. C. E. De M. Sajous** "Illuminating Engineering Nomenclature" **Mr. Lyon**	**Engineers' Club**	8.00 P.M.
Tuesday,	**May 21, 1918**	Annual Meeting Engineers' Club "War Status of Gasoline and Fuel Oil" **Mr. John D. Gill,** Member Annual Presidential Address by **Major John A. Vogleson, U.S.N.A.**	**Engineers' Club**	8.15 P.M.
Saturday,	**May 25, 1918**	Society of Automotive Engineers Annual Outing		
Tuesday,	**May 28, 1918**	American Society of Mechanical Engineers	**Engineers' Club**	8.15 P.M.

CALENDAR OF REGULAR MEETINGS

THE ENGINEERS' CLUB AND AFFILIATED SOCIETIES

1918

DAY OF MONTH AND WEEK	NAME OF SOCIETY
First Monday	**American Society of Civil Engineers**
Second Monday	**American Institute of Electrical Engineers** May 13, June 10.
Fourth Monday	**Philadelphia Safety Council** May 17, June 24.
Third Tuesday	**Engineers' Club** May 21, June 18.
Fourth Tuesday	**American Society of Mechanical Engineers** May 28, June 25.
First Wednesday	**Technology Club** May 1, June 5.
First Thursday	**Worcester Tech Club** May 2, June 6.
Second Thursday	**American Society of Heating and Ventilating Engineers** May 9, June 13.
Fourth Thursday	**Society of Automotive Engineers** May 25 (Saturday).
Third Friday	**Illuminating Engineering Society** May 17, June 21.

SECRETARY'S NOTICES

POSITIONS WANTED

Wanted—Position as manager, works manager, or general superintendent by a thoro practical and technical man; 25 years' experience on heavy, medium, small, and interchangeable work, plating, heat treatment, forge work, etc. Broad experience in shop organization and system (bonus and premium). A producer. A-1 references. Apply Engineers' Club, No. 198.

Industrial and plant engineer wants position. Thoroly experienced and trained in all branches of mill, factory, and plant equipmen, including operation and maintenance and construction of all electrical, steam, hydraulic transmissions and factory equipment. A high-grade man with a very successful record. Would consider acting as an assistant to manufacturing executive or as secretary. Apply Engineers' Club, No. 201.

Chief engineer or master mechanic, with thoro technical and practical experience covering construction, operation, and upkeep of steel plant, desires position. Specialized in metallurgical work, heating and melting furnaces. Apply Engineers' Club, No. 203.

Safety engineer, with six years' thoro technical and practical experience in this capacity with large steel works in Pennsylvania, desires position. Apply Engineers' Club, No. 204.

POSITIONS OPEN

Services of a young man desired to do estimating and selling of Asbestos Protected Metal. Apply Engineers' Club, No. 202-a.

Two draftsmen wanted; salary from $20 to $25 per week; in addition, 10 per cent. bonus for continuous attendance. Apply Engineers' Club, No. 203-a.

SECRETARY'S NOTICES

The Thirty-ninth Annual Meeting of the Club will be held on Tuesday, May 21, 1918, at 8:15 p.m., at the Club House.

The Annual Report of the Board of Directors, as published in the May Journal, will be presented.

The Annual Address will be presented by the retiring president, Major John A. Vogleson.

The report of the tellers for the ELECTION OF OFFICERS for the ensuing year will be presented. Ballots have been forwarded under separate cover. The candidates are as follows:

For President (to serve until July 1, 1919)
J. Franklin Stevens

For Vice-President (to serve until July 1, 1921)
Joseph C. Wagner

For Treasurer (to serve until July 1, 1919)
Lewis H. Kenney

For Directors-at-large (to serve until July 1, 1919—names alphabetically arranged)
William H. Connell
H. P. Gant
Walter E. Long
Paul Spencer
S. M. Swaab

H. A. Stockly, *Secretary.*

ABSTRACT OF MINUTES OF THE JOINT MEETING OF THE CLUB AND THE PHILADELPHIA SECTION OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

HELD WEDNESDAY EVENING, MARCH 27, 1918, AT WITHERSPOON HALL

The meeting was called to order at 8:25 by Mr. Joseph A. Steinmetz. About 300 members and guests were in attendance.

Corporal Frank Street, of the Strathcona Light Horse, Canadian Army, gave a short talk on the subject, "My Experiences at the Front."

Dr. S. W. Stratton, Director, U. S. Bureau of Standards, presented a paper entitled "The Relation of the Bureau of Standards to the War."

In behalf of the Club and the Philadelphia Section, American Society of Mechanical Engineers, a unanimous vote of thanks was extended to both speakers.

The meeting adjourned at 10:20 p.m.

ABSTRACT OF MINUTES OF THE REGULAR BUSINESS MEETING OF THE CLUB

HELD TUESDAY EVENING, APRIL 16, 1918

The meeting was called to order by Vice-President Yarnall at 8:20 p.m., at Witherspoon Hall. About 500 members and guests were present.

The minutes of the business meeting of March 18 and the reconvened business meeting of March 19, 1918, as printed in the Journal, were approved.

No additional nominations being received, the list of nominations as presented at the business meeting of March 18, 1918, was declared closed.

Mr. B. B. Nichols, speaker for the United States Food Administration, gave a short talk on the present food situation.

Dr. Morris Jastrow, Jr., librarian of the University of Pennsylvania and Professor of Semitic Languages, presented a paper entitled "The War and the Eastern Question."

A unanimous vote of thanks was extended to the speaker.

The meeting adjourned at 10:15 p.m.

SPECIAL MEETING OF THE BOARD OF DIRECTORS

HELD APRIL 11, 1918

The meeting was called to order at 7 P.M., with Vice-Presidents Yarnall and Eglin, Directors Gant, J. C. Wagner, Kenney, Moody, S. T. Wagner, Bullens, Hayward, Past President Swaab, Treasurer Stevens, and Secretary Stockly in attendance. Messrs. F. C. Dunlap and Wm. Pool Parker, members of the Building Committee, and Mr. W. L. Plack, architect, were also present, at the invitation of the Board. President Vogleson, Vice-President Andrews, Directors Fernald, Henderson, Forstall, Ehle, G. W. Barr, R. M. Barr, Past Presidents Ledoux and Carter were excused. Director Douglas was absent.

The minutes of the regular meeting of March 12, as issued to the members of the Board, were approved.

REPORT OF THE PRESIDENT

In accordance with authority granted at the March 12 meeting, the following have been appointed delegates to represent the Club at the annual election of trustees, Pennsylvania State College:

Charles F. Mebus.
H. C. Heaton
William D. Polk

REPORT OF THE SECRETARY

A letter from the President of the American Association of Engineers, inviting the Club to appoint one or more delegates to attend their annual convention in Chicago, May 14, 1918, to discuss certain questions pertaining to the welfare of the engineering profession, was read and the President was authorized to appoint a delegate to attend this meeting and submit a report to the Board.

The following deaths are reported:

Edward W. Barker, Jr. (Junior Member in service), on March 17, 1918.

St. John Chilton (Active Member), on March 12, 1918.

William L. Guenther (Active Member), in December, 1917.

In accordance with the action taken by the Board at its February 5, 1918, meeting, remission of dues of members in active service of the Government has been granted the following:

1st Lieut. Wm. Laird Brown
Lt.-Col H. K. Hathaway
William P. Houwen
Major E. S. Lea
Major F. B. Maltby
Private T. Elmer Moon
Capt. J. M. Ritchie
Private Albert L. Schoff
Capt. David L. Vaughan
Private George C. Wheeler
Capt. Edward R. Wood, Jr.

The following resignations were presented and accepted as of March 31, 1918:

John S. Albert
George Blair, Jr.
H. F. Blanchard
F. J. Boas
A. M. Boyd
Alfred F. Bracher
James C. Brinton
C. L. Bruff
E. F. Bush
L. M. Carpenter
Arthur L. Collins
E. L. Conwell
S. J. Cotsworth
W. T. Covert
Douglas Darling
Richard D. Davis
E. W. Deakin
Clark Dillenbeck
H. Lawrence Dowell
Walter F. Drueding
Charles K. Durbin
W. G. Dutton
John S. Ely
Conrad Engelkraut, Jr.
Harry B. Evans
J. E. Free
W. H. Gartley
W. D. Gernet
Harry Gross
Guy K. Haldeman
Stephen Harris
R. E. Hellmer
George W. Hilsee
Samuel W. MacD. Hilt
John J. L. Houston
Thomas W. Hulme
R. S. Hutchinson
W. O. Kellogg
John S. Kessler
A. Stanley Kraus
Erich Krell
Newton Lamb
B. Roscoe Leeds
W. J. Lochart
A. M. Loudenslager
James F. McCrudden
N. W. McGrew
Walter S. Miller
Walter M. Mitchell
George Mohler
Thomas Molan
Louis W. Moxey, Jr.
James M. Munck
Franklyn W. Pearce
H. C. Phillips
Francis L. Pruyn
A. F. Rader
John A. Renshaw
E. L. Rice
C. D. Rinald
Benjamin S. Robinson
Charles A. Scharfe
John D. Sells
R. E. Shaw
George T. Shegog
W. R. Simpson
Wm. C. E. Slagle
Horace K. Smith
M. R. Smith
J. V. Stanford
George B. Taylor
Amor E. Temple
Charles F. Tietze
H. M. Trueblood
W. H. Turnbull
J. W. Van Alst, Jr.
Seth M. Van Loan
P. T. Weedon
Charles A. Weeks
Barclay White
Jay M. Whitham
W. P. Wilbur
George W. Wood
Harry R. Woodall
Albert W. Zahniser

A letter was read from Mr. W. Nelson Mayhew, of the Citizens' Committee, Third Liberty Loan, stating that the response of the members of the Engineers' Club to the appeal sent out by the Liberty Loan Committee was very great, and expressing his appreciation of that fact and for the courtesy extended by the Club to the Committee in placing at their disposal the mailing list of the Club.

The annual report from the Board of Directors to the Club was presented, approved, and the Secretary authorized to publish the report in the May JOURNAL.

Mr. Ad. Fischer's name was dropped from the rolls of the Club by unanimous vote of the Board.

REPORT OF THE COMMITTEE ON HOUSE

The Board approved the recommendation of the committee that two classes of exchange privileges be arranged for, the first to cover full technical and club house privileges and to apply to the following organizations:

Engineers' Club of Dayton, Ohio.
Engineers' Club of Toronto, Canada.

Engineers' Society of Pennsylvania, Harrisburg.
Technology Club of Syracuse.
Engineers' Society of Northeastern Pennsylvania, Scranton.

The second class, to apply only to meetings and use of the library, to apply to the following:

American Institute of Electrical Engineers.
American Institute of Mining Engineers.
American Society of Civil Engineers.
American Society of Mechanical Engineers.
Boston Society of Civil Engineers.
Brooklyn Engineers' Club.
Canadian Society of Civil Engineers.
Cleveland Engineering Society.
Civil Engineers' Society of St. Paul.
Detroit Engineering Society.
Engineers' Club of Baltimore.
Engineers' Club of Kansas City.
Engineers' Club of Minneapolis.
Engineering Association of Nashville, Tennessee.
Engineers' Club of St. Louis.
Engineers' Club of Trenton.
Engineers' Society of Western Pennsylvania.
Engineers' Society of Western New York.
Louisiana Engineering Society.
Pacific Northwest Society of Engineers.
Rochester Engineering Society.
University of Pennsylvania Library.
Western Society of Engineers.

REPORT OF THE COMMITTEE ON MEMBERSHIP

At the recommendation of the Committee, the following were elected:

To *Active* Membership:

Archibald L. Altemus
Horace H. Esselstyn
John Folsz
James W. Galloway
Jesse L. Goldberger
Victor L. Sanderson
Frederick B. Sansom
John E. Snyder
Richard H. Trimble
Edward H. Warner

To *Junior* Membership:

Charles U. Bauman
Vernon C. Dilks
Thomas H. Ludwick

COMMITTEE ON LIFE MEMBERSHIPS

Mr. Eglin reported for the Committee that plans were in progress to launch a campaign to secure Life Members and the Board approved the following recommendations of the Committee:

That subscribers to Life Membership be permitted to pay Life Membership fee either in one payment or partial payments; provided, however, in the latter case that the entire payment be completed within one year from April 1, 1918; and, further,

That during the present fiscal year, on completion of payment of Life Membership fee, current dues for the year 1918–19 be remitted.

H. A. Stockly,
Secretary.

ANNUAL REPORT OF THE BOARD OF DIRECTORS

FOR THE FISCAL YEAR APRIL 1, 1917, TO MARCH 31, 1918

The Board of Directors herewith submits its report for the period April 1, 1917, to March 31, 1918, as follows:

The summary of membership on March 31, 1918, as compared with the summary of March 31, 1917, is as follows:

	March 31, 1917.			March 31, 1918.		
Class	Resident	Non-Resident	Total	Resident	Non-Resident	Total
Honorary	3	3	6	3	3	6
Active	1987	265	2252	1823	237	2060
Junior	99	0	99	150	0	150
Army and Navy	3	5	8	2	6	8
	2092	273	2365	1978	246	2224

Elected to membership during the year:

Active .... 116 Junior 60
Army and Navy 1

Resignations during the year:

Active .... 148 Junior 6
Army and Navy 1

Applications withdrawn:

Active 3

Dropped from the rolls:

Active .... 142 Junior 5

Deaths:

Active .... 12 Junior 1

The record of deaths is:

Active Members.

F. E. Bailey	Died October —, 1916.
William H. Hollar	Died December 11, 1916.
A. E. Lehman	Died April 5, 1917.
Gaston Daus	Died April 15, 1917.
George S. Cheyney	Died August 17, 1917.
R. M. Wilson	Died September 25, 1917.
Stacy Opdyke	Died October 25, 1917.
A. Theodore Bruegel	Died November 8, 1917.
Walter Lloyd Mason	Died November 15, 1917.
G. W. Creighton	Died June 2, 1917.
William L. Guenther	Died December —, 1917.
St. John Chilton	Died March 12, 1918.

Junior Member

Edward W. Barker, Jr. ...Died March 17, 1918.

During the year, affiliation with the following organizations has been accomplished.

Worcester Tech Club.
Philadelphia Safety Council.

COMMITTEE ON FINANCE

The budget prepared by the Committee and approved by the Board for the fiscal year April 1, 1918, to March 31, 1919, is as follows:

Committee on Finance (fixed charges)	$10,730.00
Committee on House:	
Restaurant revenue House revenue	1,700.00
Secretary's office	27,224.00
Committee on Papers	1,746.00
Committee on Publication:	
Operating cost	1,870.00
Committee on Library	300.00
	$41,870.00
Less revenue from house and restaurant	1,700.00
Total	$40,170.00

COMMITTEE ON HOUSE

Building operations being in progress from October, 1917, to March 31, 1918, the restaurant patronage was not entirely satisfactory during that time, and for this reason the year's showing was not as good as had been expected. During the year 24,255 meals were served to members, an average of slightly over 2000 per month. Since the new dining-room and kitchen extension have been opened there has been a marked increase in patronage.

Practically no social activities have been held in the Club during the past year, as the Committee deemed it unwise to hold such functions while the Club-house was in a more or less disordered condition. Coincident with the opening of the new dining-room, on March 5, an informal dinner was held, at which time Dr. E. J. Cattell was the principal speaker.

The new dining-room will seat comfortably 100 people, and on the evening of March 5 the room was entirely filled, and it was necessary to turn some of the late arrivals away.

It is hoped that, during the coming year, occasional dinners and other social events may be held, in order that the members-at-large may derive a more tangible benefit from the Club and may be able to become better acquainted.

In October, 1917, the Club pledged itself to observe the regulations of the United States Food Administration, and since that time has conscientiously followed the rulings made by the Food Administration.

While building operations were in progress it was not considered advisable to attempt to make any of the usual repairs, such as resurfacing the floor in the main lounging-rooms, but these repairs will be made in the near future.

There is still lack of a sufficient number of sleeping-rooms, altho the removal of the Club offices to the new building has given us two additional bedrooms.

On account of the constantly increasing cost of food, it has been found necessary, during the past year, to raise the price of luncheons and dinners from sixty cents to seventy cents, altho a platter luncheon is now being served at the price of fifty cents. It is believed the prices charged are extremely reasonable commensurate with the quality and variety of food served.

COMMITTEE ON PAPERS

The personnel of the Committee on Papers, with two exceptions, is identical with the preceding committee, and work was continued along the lines developed last year. Some of the meetings were held at Witherspoon Hall, some at the Club, and some elsewhere.

Meetings for the Junior Members were continued, with Dr. W. M. Boehm assisting them in an advisory capacity, the principal difference from last year being that the Juniors had developed an organization by electing their own officers and appointing their own committees.

Joint meetings were arranged with some of our affiliated societies, with a view to enlisting their coöperation in arranging papers.

Papers

The Committee decided that the papers this year should deal with various phases of the war, altho an occasional paper should be arranged primarily for the entertainment of the membership; that papers where the subject was treated in a popular-scientific form should be presented at Witherspoon Hall; that papers which were thoroly technical should be presented at the Club; that special meetings elsewhere should be arranged as opportunity offered, and that the speakers should be men of prominence and accustomed to public speaking. It was aimed to have the papers for the Witherspoon Hall meetings on such subjects and presented in such form as to interest a non-technical as well as a technical audience, in order to assure a good attendance.

Meetings

Some of the papers presented at the Witherspoon Hall meetings dealt with phases of the European war, and others were primarily for the entertainment of our membership. The experience of the Committee last year indicated that only papers which were of general interest to the membership would assure a good attendance. It is to be noted that the attendance at Witherspoon Hall meetings this year was considerably better than last year, and the attendance at one of the meetings was beyond the capacity of the hall. Members of our affiliated societies were invited, and members of the Club and of our affiliated societies were privileged to invite ladies to these meetings. Several cards of invitation for each meeting were sent to each member in order that he could extend invitations as he desired. When our affiliated societies were invited to any of our meetings a card of invitation was sent to each affiliated member.

The papers presented at the meetings at the Club were thoroly technical. It was considered desirable to arrange for papers of this character in order to provide as varied a program of papers as possible for our membership.

A joint meeting was held with the Manufacturers' Club at its Club-house. The speaker, Captain W. Strother Smith, U.S.N., now Admiral Smith, having promised to present an address before our Club on "Inventions Relative to War Materials," it was thought desirable to arrange for a joint meeting with the Manufacturers' Club, because the development of inventions for war purposes requires the combined effort of the engineer and the manufacturer.

A meeting was held at the University of Pennsylvania when Dr. William Curtis Farabee presented an address on "Explorations Among the Wild Tribes of South America." The doctor very courteously invited the members of the Club to inspect the University Museum after the meeting.

A meeting was held at Drexel Institute, the subjects being, "The Measure of Our Sacrifice in the Present World Conflict," by Mr. John S. Rossell, and "Some of My Observations in France," by Major W. A. Garrett.

The following meetings have been held:

Club Meetings

Club-house	7
Drexel Institute	1
Manufacturers' Club	1
University of Pennsylvania	1
Witherspoon Hall	7
Total	17
Junior Meetings	5

Joint Meetings

The Committee deemed it advisable to arrange for joint meetings with our affiliated societies, the author and subject of the paper to be made a matter of conference between the affiliated society and the Club, the view being that this arrangement would assist in developing our "affiliation idea."

The following meetings were arranged:

American Society of Mechanical Engineers, Philadelphia Section: Two joint meetings.

Worcester Tech Club: One joint meeting. Members of Club invited to one meeting.

American Institute of Electrical Engineers, Philadelphia Section: Preliminary arrangements were made but never completed.

American Society of Civil Engineers, Philadelphia Association of Members: Arrangements were completed and cancelled.

Manufacturers' Club: One joint meeting.

In accordance with our By-Laws, members of the Club are privileged to attend all meetings held at the Club-house by our affiliated societies. Announcement of all meetings of the Club and our affiliated societies are published in our Club JOURNAL.

Junior Meetings

The Committee on Papers last year initiated arrangements for Junior meetings, the object being to interest the Juniors in preparing, presenting, and discussing papers and conducting their own meetings. Attendance at these meetings was limited to Juniors and their guests. The interest of the Juniors in Club affairs should be encouraged and stimulated, partly with a view to qualifying them for committee appointments and office when they become Senior members, and partly with a view to developing loyalty to the Club.

A prize was offered last year for the best paper prepared by a Junior. The rules governing the award of prize were published in the August, 1917, JOURNAL. Arrangements were made for the Junior who won the prize to present his paper at the regular June meeting of the Club. The arrangements were continued this year.

Toward the end of last year the Juniors decided that they would continue their meetings during the present year, and perfected an organization by electing their own officers and appointing their own committees. Last fall the Juniors instituted a campaign to increase their membership, and about fifty applications were received and accepted. The membership of the Juniors previous to the campaign was about one hundred. These actions were very gratifying to the Committee as indicating the interest which had been stimulated among our Junior members.

The interest of the Juniors in these meetings has continued, and recently the Board of Directors ruled that a representative of the Juniors should be invited to attend meetings of the Board while matters which concerned the Juniors were under discussion. The suggestion was offered to the Juniors that they develop their organization to conform as closely as conditions warranted to the Club organization, and that the chairmen of their several committees consult directly with the chairmen of the corresponding Club committees in order that they could get advice and suggestions which would be of value to them.

Publicity

The Committee very carefully considered the subject of securing some publicity, particularly in relation to the papers presented before the Club. Apparently the daily press will report a paper that deals with national or local affairs and which is of general interest to the public. Papers intended primarily for the entertainment of our members or on technical subjects are not usually reported by the daily press. Some of the papers presented before the Club this year have, however, been quite extensively published in abstract by technical journals, credit always being given to our Club JOURNAL.

Possibly some of the papers would prove interesting to the public in general if published in the magazine section of some of our Sunday papers, and some similar arrangement has been made in the middle West with very gratifying results.

Schedule of Papers

AFFILIATED SOCIETIES AND CLUB

A complete schedule of the papers presented before our affiliated societies and the Club during the fiscal year beginning April 1, 1917, has been prepared from the records and is believed to be substantially correct. About seventy papers were presented, which included a very wide range of technical subjects.

CONCLUSION

Your Committee desires to acknowledge the assistance of Mr. H. A. Stockly, secretary of the Club, in arranging for speakers and meetings; Miss R. F. Vickers, secretary to the Committee on Publication, in arranging for publication the Committee announcements and papers in which the Committee was particularly interested, and Miss S. M. Snedeker, secretary to the Committee on Papers, who has so conscientiously directed our secretarial work.

Schedule of papers presented before the Engineers' Club and affiliated societies during the fiscal year beginning April 1, 1917:

ABBREVIATIONS USED

A. I. E. E.—American Institute of Electrical Engineers, Philadelphia Section.

A. S. C. E.—American Society of Civil Engineers, Philadelphia Association of Members.

A. S. H. & V. E.—American Society of Heating and Ventilating Engineers, Eastern Pennsylvania Chapter.

A. S. M. E.—American Society of Mechanical Engineers, Philadelphia Section.

C. U. C.—Columbia University Club.

D. I.—Drexel Institute.

E. C.—Engineers' Club.

E. C. Jr.—Engineers' Club, Juniors.

F. I.—Franklin Institute.

I. E. S.—Illuminating Engineering Society, Philadelphia Section.

M. C.—Manufacturers' Club.

P. S. C.—Philadelphia Safety Council.

S. A. E.—Society of Automotive Engineers, Pennsylvania Section.

T. C.—Technology Club of Philadelphia.

U. P.—University of Pennsylvania.

W. H.—Witherspoon Hall.

W. T. C.—Worcester Tech Club.

April 2	E. C.	"National Parks" by Mr. Robert Sterling Yard.	A. S. C. E.
" 4	E. C.	"Telephone Engineering" by Mr. Dodge.	T. C.
" 9	E. C.	"Underground Cables" by Mr. Henry W. Fisher.	A. I. E. E.
" 12	E. C.	"Warm Air Furnace Heating" by Mr. Irwin F. Grumbein.	A. S. H. & V. E.
" 17	E. C.	"The Inception and Development of the Submarine Boat" by Mr. John P. Holland, Jr.	E. C.
April 20	E. C.	"Automobile Headlamps" by Dr. H. P. Gage.	I. E. S.
" 23	E. C.	"Organization and Work of the Bureau of Highways" by Mr. J. B. Moran, Mr. H. I. Goldstein and Mr. H. M. Packer.	E. C. Jr.
" 24	E. C.	"Recent Developments in V-Notch Weir Measurement" by Mr. D. Robert Yarnall.	A. S. M. E.
May 2	E. C.	"The War and Its Relation to Tech Men" by Mr. Terrell, Mr. Willard and Col. Lyle.	T. C.
" 4(*a*)	W. H.	"Japan and America in the World War" by Dr. Toyokichi Iyenaga	E. C.
" 10	E. C.	"Temperature Control" by Mr. S. E. Plewes.	A. S. H. & V. E.
" 14	E. C.	"Measurement of Telephone Currents" by Mr. H. Mouradian.	A. I. E. E.
" 15	E. C.	"The Engineers' Club of Today and Tomorrow" by Mr. Emmett B. Carter (Presidential Address).	E. C.
" 18	E. C.	"A Year's Progress in the Manufacture of Mazda Lamps" by Mr. Unit Rasin; and "Elementary Talks" by Dr. H. E. Ives.	I. E. S.
" 22(*b*)	D. I.	"The Engineering of Men" by Mr. William Beahan.	A. S. M. E.
June 7	E. C.	"Ignition Systems for Automobiles" by Mr. Frank Aiken.	W. T. C.
" 19	E. C.	"Philadelphia Bridges, Past, Present and Future" by Mr. Wilmer Z. Kline (winner of Junior Prize).	E. C.
Sept. 18	E. C.	"The King of the Rails," Motion Pictures.	E. C.
" 21	E. C.	"Presidential Address," Mr. W. J. Serrill.	I. E. S.
Oct. 3	E. C.	"Technology's War Activities" by Prof. H. G. Pearson.	T. C.
" 8	E. C.	"Industrial Research" by Messrs. A. E. Kennelly, Charles E. Skinner, Frank B. Jewett.	A. I. E. E.
" 11	E. C.	"General Utilization of Pulverized Coal" by Mr. H. G. Barnhurst.	A. S. H. & V. E.
" 16(*a*)	W. H.	"The War's Effect on Merchant Shipbuilding" by Mr. Homer L. Ferguson.	A. S. M. E. & E. C.
" 19	E. C.	"Economics in the Operation of Large Lighting Installations." Messrs. C. L. Law and J. E. Buckley.	I. E. S. &. A. S. H. V.
" 25	E. C.	"Spring Design and Construction as Affecting Easy Riding" by Mr. Walter C. Keys.	S. A. E.
Nov. 1	F. I.	"Atmospheric Electricity" by W. F. G. Swann, A. R. C. S., D. Sc.	A. I. E. E. & F. I.
" 7	E. C.	"Printing, Its Art and Science" by Mr. Joseph Hays.	T. C.
" 8	E. C.	"Shop Organization and Business Efficiency" by Mr. Milton W. Franklin.	A. S. H. & V. E.
" 9(*a*)	U. P.	"Explorations among the Wild Tribes of South America" by Dr. William Curtis Farabee.	E. C.
" 12	E. C.	"A Public Utility's Method of Standardization for their Electrical Instruments" by Mr. Wm. F. Johnson.	A. I. E. E.
" 13	E. C.	"Fire Brick and Fire Cements in Oil Burning Boilers" by Mr. M. M. Kennedy; and "The Chemistry of Clays for Fire Brick and Fire Cements" by Mr. L. Zoole.	M. C. Jr.
" 16	E. C.	"Historical Lighting of Independence Square" by Mr. E. F. Kingsbury.	I. E. S.

Nov. 20(*a*)	W. H.	"Engineering and Construction Features of Cantonments" by Major Richard C. Marshall, Jr.	W. T. C. & E. C.
" 22	E. C.	"Size, Inflation Pressure and Construction of Tires as Affecting Easy Riding" by Mr. J. E. Hale.	S. A. E.
" 27	E. C.	"Manufacturing in Relation to Banking, Research and Management" by Prof. Walter Rautenstrauch.	A. S. M. E.
" 30	E. C.	"Industrial Housing with its Relation to Accident Prevention" by Mr. H. W. Forster.	P. S. C.
Dec. 5		"The Year's Work of the Advisory Commission of the Council of National Defense" by Dr. Hollis Godfrey.	T. C.
" 6	E. C.	"Modern Foundry Machinery" by Mr. Ambrose G. Warren, E. E.	W. T. C.
" 10	E. C.	"The Romance and the Practical Side of Underground Electrical Construction" by Mr. H. C. Blackwell; and "Annual Load Relief Map" by Mr. Wm. Leroy Robertson.	A. I. E. E.
" 10	M. C.	"Inventions Relative to War Material" by Capt. W. Strother Smith, U. S. N.	M. C. & E. C.
" 11	F. I.	"Offensive Against the Submarine" by Mr. Joseph A. Steinmetz.	A. S. M. E. & F. I.
" 11	E. C.	"The Measurement of the Flow of Liquids and Gases in Pipes" by Mr. Lester M. Goldsmith.	E. C. Jr.
" 13	E. C.	"Modern Heating and Ventilating Appliances for School Buildings."	A. S. H. & V. E.
" 19(*a*)	W. H.	"The War in the Air" by Mr. G. Douglas Wardrop.	E. C.
" 21	F. I.	"Color Science in Illumination" by Miss Beatrice Irwin.	I. E. S.
1918			
Jan. 3(*c*)	E. C.	"New York Catskill Mountain Water Supply" by Mr. Alfred D. Flinn.	W. T. C.
" 7(*c*)	E. C.	"The Work and Experience of the U. S. Engineer Troops in France" by Major-General C. M. Clement.	A. S. C. E.
" 10	E. C.	"The Modern Dairy" by Mr. Wm. H. Timm.	A. S. H. & V. E.
" 10	F. I.	"Physics of the Welsbach Mantle" by Herbert E. Ives, Ph.D.	I. E. S. & F. I.
" 15	E. C.	"Organization and Safety Work" by Mr. J. C. Rose.	P. S. C.
" 16(*a*)	W. H.	"Alaska from an Engineer's Viewpoint" by Mr. Howard W. DuBois.	E. C.
" 22	E. C.	"The War on Land and Sea" by Prof. Wm. L. Cathcart, Ex-naval officer.	A. S. M. E.
" 24	E. C.	"Upholstery as Affecting Easy Riding."	S. A. E.
" 28	E. C.	"Overhead Line Crossings" by Mr. Paul Spencer and Mr. G. T. Wendle.	A. I. E. E.
" 29	E. C.	"The Heavy Oil Engine" by Dr. Charles E. Lucke.	E. C.
Feb. 6	E. C.	"Engineering of Civic Efficiency" by Mr. W. R. D. Hall.	T. C.
" 6	E. C.	"Port and Terminal Facilities" by Dr. R. S. MacElwee.	E. C.
" 7	E. C.	"Compression Rheostats" by Mr. Arthur H. Allen.	W. T. C.
" 7	F. I.	"Application of Oscillatory Currents to Heating and Electric Furnace Practice" by Edwin F. Northrup, Ph.D.	A. I. E. E. & F. I.
Feb. 11	E. C.	"Some of the Broader Aspects of Utility Engineering" by Mr. J. S. Francis.	A. I. E. E.
" 12	E. C.	"Electricity as Applied to Traction" by Mr. E. M. Bredin.	E. C. Jr.
" 15	E. C.	"Lighting Curtailment" by Mr. Preston S. Miller.	I. E. S.
" 15(*a*)	W. H.	"The Influence of Topography upon the Strategy of the European War" by Prof. Frederick K. Morris.	E. C. & C. U. C.
" 19	E. C.	"Is Our Fuel Supply Nearing Exhaustion?" by Dr. Robt. H. Fernald.	E. C.
" 25	E. C.	"The Foreman in Plant Safety."	P. S. C.
" 26	E. C.	"The Income Tax, an Engineering Analysis" by Mr. Carl G. Barth.	A. S. M. E.
Mar. 6	E. C.	"Steam Turbines" by Mr. H. L. Moody.	T. C.
" 11	E. C.	"Why is an Electrical Ship" by Mr. Harry A. Horner.	A. I. E. E.
" 14	E. C.	"Our Men Over There!—Their Base Over Here!" by Mr. Joseph A. Steinmetz.	A. S. H. & V. E.
" 12	E. C.	"Crucible Process of Making Steel" by Mr. A. deMacedo; and "Waste Heat Boilers" by Mr. M. G. Bittel.	E. C. Jr.
" 15	E. C.	"The Aesthetics of Street Lighting," by Mr. S. M. Doane.	I. E. S.
" 18(*a*)	D. I.	"The Measure of our Sacrifice in the Present World Conflict" by Mr. John S. Rossell; and "Some of My Observations in France" by Major W. A. Garrett.	E. C.
" 27(*a*)	W. H.	"The Relation of the Bureau of Standards to the War" by Dr. S. W. Stratton.	A. S. M. E. & E. C.

(*a*) Members of affiliated societies invited.
(*b*) Members of Club and affiliated societies invited.
(*c*) Members of Club invited.

COMMITTEE ON PUBLICATION

During the past year the Committee published twelve issues of the JOURNAL—nine issues of sixty-eight pages each, including cover, and three issues of sixty pages each, including cover.

The make-up of each number has been about as follows: Thirty-four pages of reading matter and illustrations, seventeen pages of Club news, Secretary and Committee notices, and reports and meetings of the Affiliated Societies, and fifteen pages of advertisements, professional cards, and indices.

The total cost of the year's issue was $9734.43; advertisements and sales furnished $6835.11, and the annual budget appropriation furnished $2968.00, so that the JOURNAL during the year was published within the budget appropriation and with a credit balance of $68.68.

In the October, 1917, issue, the name of the Club's publication was changed from "Proceedings of the Engineers' Club of Philadelphia" to "The Journal of the Engineers' Club of Philadelphia and Affiliated Societies." Subsequently a new form of advertising contract and revised rates for advertising were adopted and made effective January 1, 1918, and a contract with an advertising solicitor entered into under date of March 1, 1918.

The above changes were made to increase the value of the publication and to add revenue to the Club from advertising. Effective with the change in name was the standardization of the arrangement of papers, headings, notices, etc., the principal papers being featured in the first part of the book, Club news, Affiliated Society notices, and reports of meetings published in the middle of the book, and all advertising, with the exception of preferred space, printed in the latter part of each number.

The Affiliated Societies have materially coöperated in furnishing important papers for publication. Requests are continually made for permission to reprint papers and articles appearing in the JOURNAL, and these have been uniformly and readily granted in order to give the JOURNAL wider recognition.

The Committee has endeavored not only to make the JOURNAL the medium for furnishing to the Club and Affiliated Societies' members news items, committee notices, reports, and other information relating to the various Club activities, but also to publish as promptly as possible papers and addresses presented during the year at the various Club and Affiliated Societies' meetings.

COMMITTEES ON PUBLIC RELATIONS AND CONSERVATION OF FUEL

At the request of the Committee on Public Relations, the Board of Directors appointed a Committee to formulate simple rules and regulations for the conservation of fuel. The rules as prepared were published in the Sunday edition of some of the leading newspapers, were reproduced in the JOURNAL OF THE ENGINEERS' CLUB OF PHILADELPHIA AND AFFILIATED SOCIETIES, and are being further distributed in pamphlet form by a local business firm.

Such other matters as came to the attention of the committees were reported to the Board or disposed of as seemed proper.

COMMITTEE ON BY-LAWS

The Committee, during the current year, at the request of the Finance Committee, prepared three amendments to the By-Laws.

First, a new section, namely Section 9, Article VII, providing for Life Membership; second, an addition to Section 2, Article I, limiting the number of Active resident members, and, third, a change in Section 2, Article VII, increasing the dues of Active resident members.

These three amendments were approved by the Board of Directors and adopted by the members on ballot.

COMMITTEE ON NATIONAL SERVICE

The Committee on National Service was authorized by the Executive Committee in September, 1917, and with this Committee was merged the "Committee on Coöperation for National Defense," which had done much valuable work in listing and classifying, for government service, engineers of this district.

This index was subsequently of some service to the various government departments in organizing their engineering forces during the rapid increase of their personnel, and was further placed at the disposal of the Engineering Council at New York. As the various governmental departments have perfected their organizations, there has been less need for this sort of assistance by outside parties.

Just prior to the Christmas holidays the Committee circularized the membership with a view to obtaining a Christmas Fund for the boys of Companies B and E, located at Camp Hancock, Augusta, Georgia, with the result that each one of these boys, together with their officers, received a Christmas box from the Club.

From time to time such matters as life insurance for members in the service, circularizing Club membership for Liberty Loans, Food Conservation, etc., have been referred to the Committee and disposed of as the necessities of each case seemed to require.

TRUSTEES OF THE BOND REDEMPTION FUND

RECEIPTS

1817		
March 31—Balance	$1963.08	
December 31—Coupons cashed	10.00	
1918		
January 2—Interest on deposit	67.93	
April 9—Interest on note	162.50	
April 2—Instalment	272.67	
		$2476.18

EXPENDITURES (NONE)

1918	
April 9—Balance	$2476.18

The Trustees hold two second mortgage bonds for $100 each, the note of the Club for $3250, and sundry papers of no negotiable value.

SCHEDULE "A"

STATEMENT OF

(1) REVENUE ACCOUNT (2) REVENUE ACCOUNT—GENERAL (3) ACCUMULATED FUNDS

(1) *Revenue Account for the Twelve Months Ended March 31, 1918*

Dr.			*Cr.*
Affiliated societies' expense	$553.07	Badge sales	$85.40
Auditor's expense	300.00	Billiard and pool sales	524.30
Badge purchases	91.41	Card sales	149.40
Banquet Committee	132.05	Cigar sales	4,470.52
Billiard and pool purchases	112.24	Directory sales	220.00
Buffet luncheons	159.90	Dues—members	31,655.62
Card purchases	13.50	Dues—affiliated societies	1,639.73
Cigars purchased	3,745.94	Entrance fees	1,287.50
Club development	1,091.11	Lodgings	4,240.61
Club directory	555.25	Proceedings—advertising	6,469.22
Committee on Papers' expense	463.18	Proceedings—sales	413.54
Fuel	990.15	Rentals—meeting room	758.75
Gas and electricity	1,178.15	Restaurant sales	15,867.09
House employees' meals	1,887.35	Restaurant sales—meals of employees	5,639.55
House expense	2,551.83	Telephone sales	328.54
House salaries	3,624.61	Wine sales	2,026.46
Insurance—fire, fidelity, and compensation	165.91	Loss for the twelve months ended March 31, 1918	2,070.71
Interest—first mortgage	2,160.00		
Interest—second mortgage bonds	1,856.37		
Library books and periodicals	106.51		
Library expense	71.75		
Lodgings	700.07		
Membership expense	9.75		
National defense	106.25		
Proceedings—expense	215.52		
Proceedings—publishing	9,584.63		
Proceedings—salaries	937.50		
Reserve for doubtful accounts receivable	1,607.19		
Reserve for depreciation	1,000.00		
Restaurant—employees' meals	2,586.75		
Restaurant—expense	1,897.72		
Restaurant—purchases	16,223.21		
Restaurant—salaries	5,828.30		
Secretary's office—expense	2,690.04		
Secretary's office—meals	1,117.00		
Secretary's office—salaries	6,979.64		
Speakers' expense	142.19		
Stenographer's expense	39.25		
Taxes	1,227.28		
Telephone	858.94		
Wine purchases	1,610.77		
Witherspoon Hall rent	352.13		
Sundry adjustments on accounts receivable	322.53		
	$77,846.94		$77,846.94

(2) *Revenue Account—General*

AS AT MARCH 31, 1918.

Dr.			*Cr.*
Loss from operating for the period under review, brought forward	$2,070.71	*Campaign Fund:*	
Campaign Fund:		Contributions received from members, et al.	$36,016.50
Sundry expenses	6,923.22		
Frederick Courtenay Barber—salary, expense, commission, etc.	1,879.90		
Interest on mortgage	540.00		
Insurance, taxes, etc.	327.57		
Balance, being gain, carried to Accumulated Funds	24,275.10		
	$36,016.50		$36,016.50

BALANCE SHEET

AS AT MARCH 31, 1918

Assets			
Current Assets:			
Cash:			
In banks—			
Third National Bank, Philadelphia	$720.72		
Colonial Trust Company—interest account	344.06		
On hand	400.00		
		$1,464.78	
Accounts receivable:			
Due by members	$6,868.98		
Subscription to Campaign Fund—due by members, et al.	8,761.45		
	$15,630.43		
Less reserve to provide for doubtful accounts receivable	1,500.00		
		14,130.43	
Inventory:			
Wines and liquors	$338.78		
Restaurant—provisions	216.50		
Cigars	760.79		
		1,316.07	
Insurance:			
Perpetual on club house	$1,783.80		
Furniture and fixtures	132.00		
		1,915.80	
			$18,827.08
Fixed and Other Assets:			
Real estate and buildings—1315-1317 Spruce Street, Philadelphia		$120,135.55	
Furniture and fixtures—house	$9,737.40		
Furniture and fixtures—restaurant	2,926.48		
Library	2,099.50		
	$14,763.38		
Less reserve to provide for depreciation	2,500.00		
		12,263.38	
Sinking Fund for redemption of second mortgage bonds—Hess Fund:			
Interest on deposits	$90.90		
Part principal account	909.84		
Interest on installments	1.387.51		
		2,388.25	
*Building fund notes — special fund		3,250.00	
Second mortgage bonds		200.00	
			138,237.18
Total			$157,064.26

Liabilities			
Current Liabilities:			
Accrued interest—first mortgage		$1,080.00	
Accounts payable—			
General	$8,647.81		
New building	6,789.10		
		15,436.91	
			$16,516.91
Fixed and Other Liabilities:			
Trustees for redemption fund of second mortgage bonds		$3,450.00	
First mortgage payable		60,000.00	
Second mortgage bonds		25,050.00	
			88,500.00
Accumulated funds			52,047.35
Total			$157,064.26

AUDITORS' CERTIFICATE

We certify that we have audited the financial books of the Engineers' Club of Philadelphia, for the twelve months ended March 31 1918, and that the foregoing Balance Sheet correctly sets forth the financial status of said Club as at said stated date.

THE UNITED STATES AUDIT COMPANY,
per Duncan MacInnes, President
Certified Public Accountant (N. Y.)

Respectfully submitted,
THE BOARD OF DIRECTORS
J. A. Vogleson, President, H. A. Stockly, Secretary.

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* In hands of Trustees for the redemption fund of second mortgage bonds.

COMMITTEE ON MEMBERSHIP

D. ROBERT YARNALL, Chairman

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before May 13 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

WILLIAM DAY APPLETON

1934 Chestnut Street, Philadelphia, Pa.

Engineer with Albert C. Wood.
Proposed by Louis Teal and H. F. Sanville.

FREDERICK P. BUSHNELL

6618 North Seventh Street, Philadelphia, Pa.

Secretary, Alvah Bushnell Company.
Proposed by H. F. Sanville and J. F. Stevens.

ROBERT R. ELZEY

119 Rhodes Avenue, Collingdale, Pa.

Draftsman, Tioga Steel and Iron Company.
Proposed by J. Burton Myers and Frank A. Myers.

CHARLES EBEN FISHER

3309 Arch Street, Philadelphia, Pa.

Production Engineer, Midvale Steel Company.
Proposed by H. T. McGaughan and J. L. Cozzens.

THOMAS I. GOSLIN

Care of R. D. Wood & Co., 400 Chestnut Street, Philadelphia, Pa.

Sales Engineer, R. D. Wood & Co.
Proposed by J. P. Bell, W. P. Dallett, and H. A. Jensenius.

SEDLEY HOPKINS PHINNEY

805 Franklin Bank Building, Philadelphia, Pa.

Secretary, The Bureau of Municipal Research.
Proposed by Percival M. Sax and John C. Trautwine, Jr.

CHARLES A. SCHRANZ

Care of R. D. Wood & Co., 400 Chestnut Street, Philadelphia, Pa.

Sales Engineer, R. D. Wood & Co.
Proposed by J. P. Bell, W. P. Dallett, and H. A. Jensenius.

DAVID E. SMILEY

6705 North Twelfth Street, Oak Lane, Philadelphia, Pa.

Editor, *Evening Public Ledger*.
Proposed by J. Franklin Stevens, H. F. Sanville, Wm. P. Parker, S. D. Benolieland and Lewis H. Kenney.

DONALD B. SPANOGLE

Cynwyd, Pa.

Sales Engineer, Atlantic Refining Company.
Proposed by John M. Maris and H. B. Stone.

HORACE TOMLINSON

1200 East Washington Lane, Germantown, Philadelphia, Pa.

Member of firm, George Tomlinson & Son, Contractors.
Proposed by L. F. Bacon and E. C. Thompson.

EDWIN T. WOLF

Box 85, Narberth, Montgomery County, Pa.

Salesman, E. I. duPont de Nemours & Co.
Proposed by John J. Peacock, Edward F. Cobb and F. T. Gucker.

BENJAMIN BLANCHARD WOOD

1633 North Fifteenth Street, Philadelphia, Pa.

Chief Estimator, Cramps' Shipbuilding Company.
Proposed by George M. Spear and W. A. Dobson.

FOR ELECTION TO JUNIOR MEMBERSHIP

ALFRED KUTZ ALTHOUSE

717 West Marshall Street, Norristown, Pa.

Draftsman, American International Shipbuilding Corporation.
Proposed by John P. Mudd and Emmett B. Carter.

GEORGE KADEL COLEMAN

Westville, N. J.

Engineering Assistant, Bell Telephone Company of Pennsylvania.
Proposed by J. D. Ferry and J. P. Beckman.

GEORGE ALTAIN DOYLE

5943 Osage Avenue, Philadelphia, Pa.

Engineering Assistant, Bell Telephone Company.
Proposed by W. M. Boehm, J. D. Ferry and J. P. Beckman.

FRANK WILLIAM MILLER, JR.

6701 North Sixth Street, Oak Lane, Philadelphia, Pa.

Draughtsman, Small Arms Department, Frankford Arsenal, Philadelphia, Pa.
Proposed by Moriz Bernstein and A. Sanford Craven.

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, CHAIRMAN

"From these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion; these dead shall not have died in vain."—ABRAHAM LINCOLN.

SERGEANT EDWARD W. BARKER

EARLY on March 17, 1918, Sergeant Edward Williams Barker, Junior Member, Company D, 304th Ammunition Train, died at Camp Meade, Maryland, after a brief illness.

Sergeant Barker, only child of Mr. and Mrs. John Barker, of Ashbourne, Pa., was born at Melrose, January 16, 1895. He graduated from the Cheltenham High School, Class of 1912. After a year of manual work in a local manufactory, he entered the employ of Messrs. Irwin & Leighton, and by diligent, accurate, and dependable work was rewarded by rapid promotions. He was also a graduate of the evening Course in Engineering at Temple University.

Drafted September 20, 1917, he went to Camp Meade, and was made Sergeant of his company on January 1, 1918. He held the good-will of the men, as well as the approval of his officers. A short time before being taken to the hospital, with more than five thousand others, he responded to the call for a regiment of volunteers for immediate transfer abroad into the heavy motortank service.

An escort of ten of his comrades, including four sergeants and a bugler, accompanied his remains from Camp Meade to the family burial ground at Greenmount Cemetery, Baltimore, where he was buried on March 19 with the usual military honors.

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF APRIL 25, 1918

NAME	RANK	CORPS	LOCATION
ALDRICH, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
ALLEN, H. BUTLER	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, via New York
ALLEN, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
ANDERS, D. W.	Major	Company D, 502nd Engineers	American Expeditionary Forces, France
ANDREWS, J. H. M.	Major	Ordnance R. C.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
ASPLUNDTH, E. T.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
ATTERBURY, W. W.	Brigadier-General	Director-General of Railways	France
BAKER, W. D.	2nd Lieutenant	Aviation Corps	France
BANISTER, E. S.	Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
BARNES, H. P.		Naval Flying Corps Mass. Inst. Technology	Cambridge, Mass.
BASSETT, F. H., JR.		Officers' Training School	Camp Meade, Md.
BEAR, H. K.	Lieutenant	Gas Defense Service	Camp Greenleaf, Ft. Oglethorpe, Ga.
BELL, FRANK F.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
BESCHERER, P.	2nd Lieutenant	319th Heavy Artillery	Camp Gordon, Ga.
BETUS, A. J.		111th Infantry	Camp Hancock, Augusta, Ga.
BIESTER, W. H., JR.	Corporal	"Co. E." 103rd Engineers	Camp Hancock, Augusta, Ga.
BISHOP, A. B.		U. S. Radio School	College Park, Md.
BOOZ, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	Amer. Exped. Forces, via New York
BORRESEN, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
BOYD, F. P.	Lieutenant	U. S. Naval Reserve Force	Submarine Base, New London, Conn.
BOYD, G.	1st Sergeant	Overseas Repair Section No. 1	Gas Defense Service, Medical Corps
BRADFORD, J. S.	Major	103rd Engineers	Camp Hancock, Augusta, Ga.
BRADT, MORRIS	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
BRANSOME, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
BREAM, C. C.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
BREEN, J. W.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York

Brewer, P. C., Jr.	2nd Lieutenant	307th Engineers	Camp Gordon, Atlanta, Ga.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Britten, D. L.	Captain	Ordnance Officers' Reserve Corps	Inspector of Ordnance, Haddon Apts., Cleveland, O.
Broadhead, Alex.		19th Reserve Engineers	American Expeditionary Forces, via New York
Broderick, D. F.	Major	Ordnance Officers' Reserve Corps	Rock Island Arsenal, Rockland, Ill.
Brown, J. A.	Major	Ordnance Officers' Reserve Corps	Smithtown, L. I., New York
Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier-General W. W. Atterbury
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, via New York
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. P.	2nd Lieutenant	462nd Co. (Motorcycles), N. A.	Fort Myer, Va.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.		Carriage Division, F. A. Section	Washington, D. C.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Chance, T. M.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Childs, H. P.	1st Lieutenant	23rd Engineers	American Expeditionary Forces, France
Clark, J. W.		Russian Railway Service	Nagasaki, Japan
Cleeland, R.	Cadet Engineer	S. S. Neuse	Care U. S. Shipping Board
Colgan, R. J	Captain	11th Regiment Engineers	Care of Adjutant-Gen'l, Washington, D. C.
Craig, Coulter	Captain	Ordnance Officers' Reserve Corps Supply Division	Office, Chief of Ordnance Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	Camp Hancock, Augusta, Ga.
Crowther, E. C.	1st Sergeant	Base Hospital No. 38	Second Regiment, N. G. P., Armory, Philadelphia
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Chamber of Commerce Bldg., Pittsburgh, Pa.
Cutler, James B.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Darlington, I. G.	1st Lieutenant	Gun Section, Production Division	Washington, D. C.
Day, R. F.	2nd Lieutenant	Aviation Corps	3rd Squadron, Ellington Flying Field, Houston, Texas
Derby, C. F.	Captain	Ordnance Officers' Reserve Corps	Camp Lee, Petersburg, Va.
Dill, C. M.		First Battery, Reserve Officers' Training Camp	Camp Lee, Petersburg, Va
Donnelly, J. B.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Doyle, T. H.	2nd Lieutenant	U. S. Quartermaster's Corps	Overseas Service
Dunlap, V. R.	Lieutenant (Jr.)	Ass't Civil Engineer, U. S. N.	Naval Air Station, Pensacola, Fla.
Dunn, M. L.	Ensign	"U. S. S. Connecticut"	Care Postmaster, N. Y.
*Dyson, C. W.	Rear Admiral	Bureau of Steam Engineering, U. S. N.	Washington, D. C.
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.
Elcock, Chas.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Farr, Roy S.	2nd Lieutenant	301st Engineers' Train	Camp Devens, Ayer, Mass.
Faust, W. D.		103rd Engineers	Camp Hancock, Augusta, Ga.
Fenton, Powell		Aviation Corps	France
Ferree, D. S.	Engineer Officer	Aviation Section, Signal Corps	M. I. T. School of Military Aeronautics, Cambridge, Mass.
Filbert, C. B.	Captain	41st Engineers	American Expeditionary Forces, France
Fish, W. N	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Maryland
Forster, A. O.	Captain	Construction Branch Quartermaster's Corps, N. A	Washington, D. C.
Frank, A.	Corporal	1st Replacement Regiment Engineers—Co. "A"	Fort Foote, Maryland
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	P. O. 717, American Expeditionary Forces, France
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gauthier, Jordan	2nd Lieutenant	56th Engineers	Washington, D. C.
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Getz, Ralph F.	2nd Lieutenant	32nd Engineers	Camp Grant, Ill.
Gilbert, W. T.		21st Railway Engineers	American Expeditionary Forces, via New York
Gillam, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Goldsmith, H. F.		Naval Aviation Training School	Cambridge, Mass.
Goodwin, H., Jr.	Lieutenant	U. S. Naval Reserve Force	
Gracey, A. L.	Private	Advance Ordnance Depot No. 4	American Expeditionary Forces, via New York
Graham, W. R.	1st Lieutenant	Aviation Section Signal Officers' Reserve	Aviation Mob. Camp, Camp Sevier, Greenville
Gravell, W. H.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Gray, B. D.	Major	Signal Corps, U. S. A.	Adams Bldg., Washington, D. C.
Gribbel, W. G.	Captain	30th Engineers	American Expeditionary Forces, via New York
*Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C.
Grossman, P. R.	Private	447th Depot Detachment Engineers	Camp Devens, Ayer, Mass.
Gwilliam, Mark R. M.	1st Lieutenant	21st U. S. Infantry	San Diego, Calif.

Hall, W. A.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	105th Engineers	Camp Sevier, Greenville, S. C.
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hathaway, H. K.	Lieut.-Colonel	Ordnance N. A.	Washington, D. C.
Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
Heger, J.	Lieutenant	Engineers' Depot	Washington, D. C.
Henderson, S. D.	Private	304th Engineers	Camp Meade, Admiral, Md.
Henry, J. C.		Headquarters Dep't 19th Reserve Engineers	Amer. Exp. Forces, via New York
Hetherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Infantry	Charlotte, Ga.
Hollenback, E. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.	1st Lieutenant	Dental Corps, 28th Division	Camp Hancock, Augusta, Ga.
Houwen, W. P.	C. M. A. A.	United States Navy Air Station	Cape May, N. J.
Hulme, Norman	1st Lieutenant	458th Truck Co.	Fort Myer, Va.
Hyland, G. N.	2nd Lieutenant	Aviation Concentration Camp	Camp Dick, Dallas, Texas
Jaques, J. D.	Lieutenant	U. S. N. R. F., Public Works Dept.	Navy Yard, Boston, Mass.
John, R. R.		Officers' Training School for Coast Artillery	Fortress Monroe, Va.
Jones, Jonathan	Captain	23rd Regiment Engineers	American Expeditionary Forces, via New York
Kennedy, J. H.		Aviation Section, Signal Corps	American Expeditionary Forces, via New York
Kern, F. X.	Lieutenant	23rd Regiment Engineers	American Expeditionary Forces, via New York
Klein, A. C.	Lieutenant	Production Section, Gun Division	Office, Chief of Ordnance, Washington, D. C.
Kneass, E.	Ensign	U. S. Submarine Base	New London, Conn.
Knight, C. C., Jr.	Lieutenant	318th Field Artillery, N. A.	Camp Jackson, S. C.
Koelle, W. F. B.	Sergeant	Signal Corps	Washington, D. C
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	Amer. Exp. Forces, via New York
Lawrence, G. E.	Lieutenant J. G.	U. S. Naval Res. Force	U. S. S. "Nokomis," European Waters, care Postmaster, N. Y.
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Levin, J.	2nd Lieutenant	Coast Artillery Reserve Corps	Fort Hancock, N. J.
Loeb, A. H.		154th Depot Brigade 1st Detachment	Camp Meade, Admiral, Md.
Lynch, N. H.		"F" Co., 6th U. S. Engineers	American Expeditionary Forces, France
MacGarrigle, G. L.	Private	Company "B," 103rd Engineers	Camp Hancock, Augusta, Ga.
Magee, J. W.	1st Lieutenant	446th Engineers' Pontoon Train	Washington Barracks, D. C.
Mallon, G. J.	Lieutenant (Jr.)	U. S. Naval Reserve Force	U. S. S. "Mt. Vernon," care of Postmaster, N. Y.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Mardaga, L.	Ensign	U. S. Naval Reserve Force	Asst. Naval Inspector of Ordnance, Alloy Steel Forging Plant, Carnegie, Pa.
Martin, T. S., 3rd	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Mayburry, W. G., Jr.	Lieutenant	334th Field Artillery, National Army	Camp Pike, Ark.
McCausland, J. R.	Master Engineer Senior Grade		U. S. Post Office 701, R. T. O., American Expeditionary Forces, France
McClintock, J. L.		U. S. Navy Radio Station	Atlantic City, N. J.
McCord, J. B.	Lieutenant-Colonel	Ordnance N. A.	American Expeditionary Forces, France
McCormick, J. C.	1st Lieutenant	Engineer Officers' Reserve Corps	Amer. Exp. Forces, via New York
McCoy, J. F.	2nd Lieutenant	Aviation Section, Signal Corps	
McGarrigle, J. J.	1st Lieutenant	Anti-Aircraft, Artillery C. A. C.	American Expeditionary Forces, France
McMillan, H. L.	Major	Engineers	Camp Humphries, Va.
Millar, E. A., Jr.	1st Lieutenant	Ordnance Officers' Reserve	Camp Hancock, Augusta, Ga.
Mohr, C. F.	Private	Co. "B," 45th Engineers	Camp Accotink, Va.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Moon, T. E.	Corporal	119th Ordnance Depot Co.	Camp Hancock, Augusta, Ga.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Murphy, H. C.	Ensign	U. S. Navy	Room 6030, New Interior Bldg., Washington, D. C.
Meyers, W. C.	Captain	Ordnance Officers' Reserve	Inspection Division Standard Steel Car Co. Butler, Pa.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	1st Lieutenant	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixon-Miller, M.	Captain	Company "B," 501st Engineers	France
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
***Oakes, J. C.**	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Orr, M. W.		First Battery, Officers' Training School	Camp Meade, Md.
***Otwell, Curtis W.**	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Perry, Edward	Sergeant	Motor Truck Company No. 329	Camp Lee, Petersburg, Va.
Peterman, J. M.		Co. "G," 316th Infantry	Camp Meade, Admiral, Md.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pierce, D. T.		American Red Cross	France

Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Prichett, F. B.		103rd Trench Mortar Battery	Camp Hancock, Augusta, Ga.
Prince, H. W.		Squadron 80	Camp Eimerman, Fort Worth, Texas
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	79th Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	19th Reserve Engineers	American Expeditionary Forces, via New York
Reed, Thomas	Captain	Ordnance Officers' Reserve Corp	Inspector of Ordnance. Walter Scott & Company, Plainfield, N. J.
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Reninger, H. A.	Major	Headquarters, 103rd Ammunition Train, 28th Div.	Camp Hancock, Augusta, Ga.
Ridge, R. S.	Sergeant	23rd Engineers	Camp Meade, Admiral, Md.
Ridgway, J. J.	1st Lieutenant	Co. "F," 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.	Private	201st Aero Squadron	12 W. 95th St., New York City
Roof, J. C.	Captain	17th Engineers	France
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Russell, J. A.	Lieutenant	Ass't Div. Engineer, 86th Division, N. A.	Camp Grant, Rockford, Ill.
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Satterwhite, R. L., Jr.		Naval Reserve Flying Corps	Cape May, N. J.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	Washington, D. C.
Schaum, O. W.	Aeronautical Mechanical Engineer	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
Schoch, J. B.	Lieutenant	109th U. S. Infantry	Camp Hancock, Augusta, Ga.
Scull, A. H.	Lieutenant	Railroad Transportation Corps	American Expeditionary Forces, via New York
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defense Service, Med. Dept., U. S. A.	Washington, D. C.
Sheahan, J. C.	2nd Lieutenant	Co. 11, Section B, Bldg. 6	Camp Jos. E. Johnston, Jacksonville, Fla.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Smith, A. H.	Sergeant	Utilities Detachment Quartermaster's Corps	Barracks B 104, Camp Meade, Admiral, Md.
*Smith, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	Overseas Service
Spillan, J. J. D.	Sergeant	Hq. 53, Brig. F. A.	Camp Hancock, Augusta, Ga.
St. John Everett	1st Lieutenant	Coast Artillery Reserve Corps	Fort duPont, Delaware
*Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	Major	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Engineer Officers' Training Camp	Belvoir, Va
Thacher, C. H.	2nd Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
*Thomas, R. S.	Colonel	22nd Engineers	Camp Sheridan, Montgomery, Ala.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Corporal	Class "B," Ordnance Det. N. A.	Gunpowder Reservation, Edgewood, Md.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Maine"
Truhan, L. J.		Reserve Officers' Barracks "B," Room No. 373	Naval Academy, Annapolis, Md.
Uhler, W. D.	Major	Quartermaster Corps, N. A.	Washington, D. C.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal
Vaughan, D. L.	Captain	Quartermaster's Corps N. A.	Camp Logan, Houston, Texas
Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Coast Artillery	Fort Greble, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces via New York
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	Engineer Officers' Reserve Corps	France
Wentz, E. M.	Asst. Paymaster	U. S. Naval Reserve Force	U. S. S. Topila, care of Postmaster, N. Y. C.
Wheeler, G. C.		Presbyterian Hospital Unit	American Expeditionary Forces, France
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	Camp Hancock, Augusta, Ga.
White, J. A. Jr.	Private	Co. "A" 109th Infantry	Camp Hancock, Augusta, Ga.
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C
Wilkinson, R. W.		Engineers' Training School	Carnegie Institute, New York
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	Office of Inspector of Ordnance, U. S. A. Highland Park, Michigan
Wood, E. R. Jr.	Captain	18th Field Artillery, N. A.	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	Coast Artillery School	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Alex. Remount Depot, Macon, Ga.
Zeckwer, J.R.*	Ensign	U. S. Naval Reserve Force	Ship Inspection Office, Philadelphia
Zinn, George A.	Colonel	District Engineers' Office, Custom House	Portland, Oregon

* Army and Navy member.

JUNIOR SECTION

DR. W. M. BOEHM, Chairman *Ex Officio* H. I. GOLDSTEIN, Chairman A. P. GODSHO, Secretary

THE regular monthly meeting of the Junior Section was held at the Club-house on April 9, at 8.15 P.M., Chairman Goldstein presiding.

In spite of the very inclement weather there was a good attendance, and those present were amply repaid by the interesting paper presented.

The Chairman announced that, inasmuch as Mr. W. Z. Kline was the only candidate for chairman, the election could only be a ratification of the nominating committee's choice. He therefore announced Mr. Kline's election as chairman for next year. Mr. Kline then made some remarks, in which he expressed his appreciation of the honor conferred on him and his earnest purpose to have the Juniors prosper during the coming year as much as, and if possible more than, during the year past. He referred particularly to the sociability feature, which he said he would endeavor to emphasize.

Mr. Kline, chairman of the Papers Committee, read a formal report of the work of his committee. During the year, including the paper read April 9, seven papers had been presented. A particular effort had been made to form a well-balanced program by having the schedule cover the entire field of engineering, so that, no matter what field a member might be in, some of the papers would be of particular interest to him. The speakers had all made their papers reasonably short and concise.

Mr. Kline stated that the Committee had been somewhat handicapped by the fact that the Juniors were not so well acquainted. The war also caused trouble, inasmuch as a prospective speaker might be in Philadelphia to-day and to-morrow be in uniform somewhere else; other prospective speakers were refused permission to talk by their employers, while others were limited in their remarks.

Mr. Boettcher, chairman of the By-Laws Committee, reported that the amendment recommended by his committee with reference to raising Junior age limit and dues had been presented to the By-Laws Committee of the Senior body, and would be put before the Board of Directors with that committee's recommendation in due time.

Mr. Bittel, chairman of the Club and Public Relations Committee, reported the result of his work in attempting to secure a more direct connecting link between the Senior and the Junior bodies. The Board of Directors, at its meeting, decided that the Junior committees should work in closer touch with the chairmen of the various Senior committees, to whom they should go for advice and instructions. It was also decided that at any Board meeting, when matters pertaining to the Juniors were under discussion, a Junior appointed by the Chairman of the Junior Section could be present. Mr. Bittel stated that this, in his opinion, was eminently satisfactory, and that now any matter could be presented to the proper authorities direct without the necessity of having it go thru an intermediary.

The paper of the evening was then presented by Mr. R. B. Nicholson, entitled "The Standardization of Steel Mill Building Construction."

The points brought out by Mr. Nicholson's paper were that the standardization of mill buildings follows naturally on standard methods and standard parts now used in structural work. A careful study and analysis of many existing buildings brings out the fact that many parts of these buildings are alike, even in many highly specialized buildings.

Standardization of this type of construction possesses three distinct advantages; *i.e.*, speed of construction, lower cost, and reduction in the labor force required.

Speed of construction is obtained by having plans ready, costs figured, roof trusses, beams, columns, and sash ready fabricated to be shipped to the job and assembled on the site.

The second advantage, or lower cost, depends on the activity of business. When building work is active, prices for material and labor advance until they reach a prohibitive figure, work stops, and a period of lower prices sets in. Buying material when prices are low and carrying it in stock for future use reduces the cost and saves money for producer and consumer. This is especially possible with standardized work. Again, the cost of plans that are used many times for different jobs is practically absorbed.

The third advantage, reduction in labor force, lies in the standard operation repeated over and over until it becomes second nature, thus permitting greater speed with fewer men.

Standard types of buildings show efficient construction for widely varying uses, and range from small machine shops and mills covering a few hundred square feet of space to foundries, forge shops, and factories covering acres of ground, these being merely the repetition of the same type or combinations of the several types.

The illustrations shown by Mr. Nicholson were not temporary shacks, but substantial structures for permanent use.

There was a very lively discussion of Mr. Nicholson's paper, showing the interest which it aroused.

The competition for the Junior Prize closed Monday

(Continued on Page 263)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS .·. PHILADELPHIA SECTION

Lewis F. Moody, Chairman. John P. Mudd, Secretary, Midvale Steel Company, Nicetown, Pa.

On March 27 the local section again joined hands with the Engineers' Club in holding a meeting at Witherspoon Hall. Mr. J. A. Steinmetz presided.

Dr. S. W. Stratton, of Washington, D. C., who is well known thru his connection with the United States Bureau of Standards, delivered an excellent address dealing with the usefulness of the Bureau on war work. His address was profusely illustrated with lantern slides, showing instruments of precision used in calibrations and comparisons. This paper will be published in a subsequent issue of the Journal.

Corporal Street, a Canadian in the British Army, and who is attached to the British Recruiting Mission with Col. St. George Loftus Steel, gave a patriotic talk at the close of Doctor Stratton's paper.

Altho the April meeting will have been held before the Journal reaches the members, it will be too late for a report of it in this issue. A dinner meeting at the Adelphia Hotel is planned, at which the Council of the National Society will be our guests.

The Committee is as follows: T. C. McBride (chairman), W. D. Disston, W. C. L. Eglin, Strickland L. Kneass, Coleman Sellers, Jr., S. M. Vauclain, A. L. Church, A. C. Dinkey, Dr. Hollis Godfrey, Wilfred Lewis, and W. S. Twining.

The Executive Committee desires to thank the following men for assisting in making arrangements for the meeting: C. N. Lauer, P. P. Henshall, Capt. H. Tilson, Chester Larner, Leo Loeb, A. C. Jackson, L. L. Hepburn, L. H. Kenney, and H. H. Esselstyn.

The War Department has written the secretary of the local section, urging whatever action, thru announcements at its meetings or publications, may be necessary to help recruit men for non-military positions in the Ordnance Department. The word has been passed along that for some of the positions there is almost no limit to the number of men which can be utilized.

The following positions are open and will be filled thru Civil Service examination. Entrance compensation ranges from $800 to $6000 per year.

An announcement giving details of requirements may be examined at the office of the Society, or copies may be obtained by writing to Civilians Personnel Section, Office of Chief of Ordnance, U. S. Army, 1333 F Street, N. W., Washington, D. C., and referring to letter V-230-H.

Position	Entrance Compensation	Announcement No.
Inspector, powder and explosives chemists	$1600-2400	108
Assistant inspector, powder and explosives chemists	1000-1600	108
Assistant inspector, machine guns	1200-1500	134
Assistant inspector, artillery wheels, gun carriage forgings, castings, and steel mill products	1200-1500	139
Inspector, gun carriages	1800-2400	136
Assistant inspector, gun carriages	1200-1500	136
Assistant inspector, carriage parts	1000-1500	155
Junior accountant	1200-1800	155
Cost accountant supervisor	2400-6000	157
Mechanical draftsman	800-1800	242
Munitions inspector, artillery ammunition	1600-2400	1240
Inspector, small arms	1600-2400	1550
Assistant inspector, small arms	800-1600	1550
Metallurgical chemist	1600-2400	1617
Assistant metallurgical chemist	1000-1600	1617
Clerk qualified in statistics or accounting	1000-1800	2030
Inspector, small arms ammunition	1500-2400	2078
Assistant inspector, small arms ammunition	800-1500	2078
Statistican	1800 and expenses, upward and downward.	2147
Assistant inspector of cannon (forging operations)	1200-2400	2179
Assistant inspector of cannon (machining operations)	1200-2400	2179
Assistant inspector of gunfire control instruments	1200-1500	2232
Production clerk	1500	2253
Inspector, material for small arms	1600-2400	2234
Assistant inspector for small arms	1000-1600	2259
Accessory inspector, small arms ammunition	1200-1900	2259
Ballistic inspector, small arms ammunition	1200-2100	2259

JUNIOR SECTION

(Continued from Page 262)

evening, April 15, five papers having been submitted. While the number falls short of last year, it was not unexpected, because a large number of the boys are in the Service, and those that are not have been much busier than in previous years. The papers submitted were:

"Electricity as Applied to Traction," by Mr. Edward M. Bredin.

"A Radical Change in the Stern Frame and Rudder on Some of Our New Merchant Fleet," by Mr. Ellis G. Joseph.

"Industrial Chemical Structures," by Mr. Jerome S. Marcus.

"The Development of a Pitot Tube for Accurate Measurement of Gas and Air Flow," by Mr. Lester M. Goldsmith.

"Powdered Coal," by Mr. Martin G. Bittel.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ∴ PHILADELPHIA SECTION

NATHAN HAYWARD, Chairman

H. MOURADIAN, Secretary, 1631 Arch Street

THE May meeting will be held at the Engineers' Club on May 13. The subject of the paper to be presented is "The Big Creek Plant of the Southern California Edison Company," by Mr. J. H. Anderton.

The April meeting was held on the 8th, at the Engineers' Club. Mr. H. S. Warren, of the American Telephone and Telegraph Company, read a very interesting paper on the "Inductive Interference of Alternating-current Railroads upon Communication Lines." Mr. Warren outlined, in an introduction, the general nature of the inductive interference effects experienced on communication lines on account of the parallelism of power lines, and the specific difficulties of the problem where alternating-current railroads are involved in the interference. Such difficulties, it was outlined, arise mainly thru the earth return of large amounts of current and thru the difficulty of providing adequate separation when the railroad company and the telephone utility are serving the same community. He spoke particularly in regard to the difficulties of coping with the heavy interference effects produced at times of abnormal operation of the railroad (short circuits, etc.). He described several specific cases of electrification and the methods used in each case to meet the interference, and stated that progress had been made and new methods developed, but that in some cases the application of the methods required considerable expenditure of money.

The paper was discussed by Messrs. S. Whitingdon, A. W. Copley, H. Mouradian, W. C. L. Eglin, P. Spencer, F. H. Shepard, and Professor Scott.

PHILADELPHIA SAFETY COUNCIL

LOCAL SECTION No. 7 OF NATIONAL SAFETY COUNCIL

J. F. CONNER, President

J. P. MUDD, Secretary-Treasurer,
The Midvale Steel Co., P. O. Box 1322

THE meeting of the Philadelphia Safety Council held on March 25 was an excellent one.

The evening was given over to a discussion on the prevention of foundry accidents. Mr. Alexander E. Outerbridge, Jr., metallurgist of William Sellers & Co., gave a paper on the subject, illustrating it with lantern slides. Mr. H. B. Harmer, of the Philadelphia Electric Company, presided. The following took part in the discussion: Mr. C. C. Black, Department of Labor and Industry; Mr. Schilling, formerly of the National Museum of Safety; Mr. Edwin Elliott, Midvale Steel and Ordnance Company; Mr. Charles Lobs, Midvale Steel and Ordnance Company; Mr. C. Howard Williams, American Pulley Company; Mr. Otte, William Sellers & Co., and Mr. H. B. Harmer, Philadelphia Electric Company.

An abstract of Professor Outerbridge's paper will be published in the June issue of the JOURNAL.

The April meeting, which will be held after this issue of the JOURNAL goes to press, but before it reaches the members, shows every indication of being a banner affair. A dinner in the new dining-room of the Engineers' Club will precede the meeting.

ILLUMINATING ENGINEERING SOCIETY

PHILADELPHIA SECTION

Walton Forstall, Chairman **Unit Rasin**, Secretary, 1411 Widener Bldg.

MAY MEETING

THE May meeting of the Philadelphia Section of the Illuminating Engineering Society will be held on the 17th, at the Engineers' Club, and will be a joint meeting with the Philadelphia Safety Council.

The meeting will be opened by Mr. Lyon, who will give another talk on "Illuminating Engineering Nomenclature." The paper of the evening will be by Dr. C. E. DeM. Sajous on "The Relation of Light to Health." Doctor Sajous, who is well qualified to speak on this subject, will first state the prevailing knowledge concerning the influence of light upon the tissue-cell. The vital process as now interpreted affords no logical link between light-energy and vital phenomena. He will give the established facts that offer a solid foundation for a rational interpretation of the vital process. The influence of light-energy upon this process under normal and morbid conditions will be discussed, as well as the preservation of health by a radical supply of light-energy. How diseases are antagonized by heat and radiant energy, the underlying purposes of fever, and the effect of solar light and other forms of radiant energy as curative agents will be brought out in this paper.

The usual dinner at the Club will precede the meeting, to which all of those intending to attend the meeting are invited, and are requested to notify the office of the Club to this effect.

APRIL MEETING

The April meeting of the Philadelphia Section, on the 19th, was a most interesting and successful occasion. The 102 members and visitors present included a number of ladies and left few vacant seats in the room.

The paper of the evening was on "The Progress of Illuminating Engineering During the Past Year," and was presented jointly by Mr. F. E. Cady, of the National Lamp Works, of Cleveland, Ohio, and Mr. R. F. Pierce, of the Welsbach Company.

Mr. Pierce spoke of the progress in gas manufacture and lighting, the principal development, from an economic standpoint, being an apparatus devised for generating gas from millions of tons of straw annually burned in Canada in order to clear the ground.

Mr. Cady spoke on the development in electric lighting, mentioning many different forms of lamps and devices which have recently been placed upon the market. His talk was illustrated by lantern slides, as well as by an extensive exhibition of the devices referred to, which had been collected by the Exhibition Committee.

Following these speakers, Mrs. Mary Hallock Greenewalt gave a talk on "The Relation of Light to Music." She spoke on the effect of light in Nature on birds and flowers, and compared the various colors with the tones in music. She illustrated her point by playing Beethoven's "Moonlight Sonata," with an accompaniment of bluish light which increased and decreased with the music. She then played one of De Bussy's compositions, and at the same time was enveloped in varying shades of color which were intended to give a visible expression to the musical notes. This effect was produced by means of colored screens passing in front of an electric lamp, and the suggestion was made that such effects should be worked out for each composition and results obtained automatically by the various forms of player pianos.

Preceding the meeting the usual dinner was held in the Club's dining-room, which was attended by twenty-eight members and guests.

SOCIETY OF AUTOMOTIVE ENGINEERS

PENNSYLVANIA SECTION

John W. Watson, Chairman. **A. K. Brumbaugh**, Secretary, Autocar Co., Ardmore, Pa.

THE last meeting of the Pennsylvania Section of the Society of Automotive Engineers for the season will be held April 25 and will take the form of a business meeting, with election of officers, which will be followed by a patriotic meeting, with some interesting addresses from soldiers who have been at the front.

The annual outing will be held on May 25.

Pag. o.k.

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-6 JUNE, 1918 NO. 163

THE HEAVY OIL ENGINE*

By CHARLES E. LUCKE

PROFESSOR MECHANICAL ENGINEERING, COLUMBIA UNIVERSITY,
NEW YORK CITY

THE heavy oil engine is of particular interest at this time because those who are familiar with the problem believe a change is coming in the situation. It is my intention to present, in a more or less informal way, some of the ideas involved in the development up to the present time and also those which lead us to believe that a change is about to take place, and in about what direction. What I say is somewhat in the nature of a prediction, altho he is a bold man who undertakes to make a prediction on these matters. Nevertheless, I am inclined to have a little more confidence than usual because about a year ago I talked to you here about aeronautical engines, and showed those who were not already familiar with that fact from what a chaotic state the art of aeronautical engine construction was then emerging, and ventured to lay down some general lines of practice that seemed to be proper and a good basis for future work to follow.

Since that time this country has been drawn into the great war, and likewise since then the Liberty motor has been designed and put on a manufacturing basis. A good many ideas that were presented a year ago before the inception of that motor, and before there were standards of any kind, have been incorporated in it. A number of the things which were then not standard and which were recommended as standard have since become standard.

I feel, therefore, somewhat more confident in the sort of prediction to be made to-night on the heavy oil engine.

It may be of interest for me also to say here that as a result of the war my entire time, to the exclusion of all other things, has been devoted to the subject of internal-combustion engines for the navy service. The Navy Department has established at Columbia—about the Mechanical Engineering Department, as a nucleus—the official United States Navy Gas Engine School, and over nine hundred men have been given, all without any internal-combustion experience before they came, a four weeks' finishing course of training and have been turned out into the service. Of those men, the leading engineers of over two hundred of the submarine chasers form a part. That work is now going on and will continue until all these boats have been manned with trained men.

It is interesting to note, also, that these boats were non-existent a year ago; they did not even exist completely on paper, and before a year will have passed from the time when they were paper things there will have been completed, and in the water and completely manned and officered by trained men, over three hundred of them. Even tho that is a small matter in the naval program, it is nevertheless an accomplishment that all ought to feel proud of.

The gas engine school at Columbia University is also now undertaking to train the engineers and leading mechanics to take charge of the motors for the navy foreign flying base station service. I mention that because I want something from you in that connection; to help secure fine, competent internal-combustion engine men who are also machinists, and therefore the kind of men that can safely be trusted with the enormous responsibility of proper maintenance of an aeronautical motor, the failure of which may cause the sacrifice of life. We will not undertake to train any man who is not at the start a pretty good man—at least from the experience standpoint. We are not finding these men at the present time as fast as we need them, so I am mentioning this fact with the idea that those of you who are here and who know such men will let me have their names, or at least tell them to apply for that class of service, if they like it, and I will see what can be done to bring them in. The leading men will receive the rank of Ensign in Class 5, the Naval Reserve Flying Corps, and will have the job of Engineer Officer.

To return to the subject, the heavy oil engine. The heavy oil engine in this country has never amounted to very much. That fact itself should prompt some inquiry, because this country is the home of petroleum.

The heavy oil engine as an internal-combustion engine has so far proved itself to be capable of the highest known thermal efficiency in transforming the heat of combustion into work. Efficiencies approaching 40 per cent. are normal, and in some rare cases this is exceeded. This is not equaled by any other system that has ever been produced.

Putting those two facts side by side, you will see a cause for wonder at once. Here is America producing more petroleum than any other country in the world, and doing it for a long time back—something like fifty years—and yet the motor that operates with this oil—the most efficient known—the heavy oil engine in this land of petroleum is, compared with other classes of machinery, practically a failure. It is a failure in the sense that the business of producing it has not expanded materially, and it has been in general an unprofitable business. No one in this country has made much, if any, money in building oil engines, and a great many who have thought of going into the business with excellent prospects, good plans, and plenty of capital behind them finally decided not to do so on the record of failure to produce dividends on the part of those who are already in.

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* Presented before the Engineers' Club, January 29, 1918.

There has been from the beginning great interest in the oil engine. It is a thing attractive to the mind. Everybody thinks about it. And yet, on the commercial side, there has been very little demand—not sufficient demand anywhere to warrant any really large establishment confining itself to the production of oil engines with a competent engineering staff and research department such as would be necessary to do the thing right. This lack of demand is rather difficult to explain, but it is nevertheless real. Assume it to be a fact, without investigation, and put it down as the first of the various causes for lack of development. The next cause is the fact that this is the land of petroleum, and therefore the land where petroleum and its products are held in least value. In other words, we are prodigal of petroleum and have not the inducement, by reason of our multiple supply, to economize it. In the place where oil is so plentiful naturally it is not regarded as a valuable product—not nearly so much as in a distant country, where its cost is high. That fact makes the high efficiency mentioned before lose its attractions, and when it is remembered that the machine to produce this high efficiency is a costly machine, therein lies the elements of financial balance that turn the wrong way.

The cost of power, when it is the controlling factor—and that is usually the case in stationary installations—is made up of two charges: fixed and operating. The fixed charges are based primarily on the first cost of the engine, and the heavy oil engine has always been an expensive engine—never less than $60 per horsepower and often as much as $80 per horsepower. On the other side is the operating expense, the principal item of which usually is the cost of fuel. The more highly efficient is the engine, in fuel consumption, the less will be the fuel cost per horsepower-hour, and therefore the more prominently this heavy fixed charge will stand out.

In all cases where the cost of power is the controlling factor these financial facts are to be laid beside the fact of the lack of demand for these oil engines. Nevertheless, as time goes on, inventors, designers, and research men are not deterred from trying out schemes, so that, in spite of this lack of financial and business encouragement, there is a very considerable degree of progress—much slower than it ought to be, but nevertheless real. Unfortunately, in this case the public in general is not informed about this progress, and therefore when, due to a change in economic conditions, the time comes to make use of all the available information on the subject, we suddenly wake up to the fact that it is in the hands of a few people and the rest of the public knows nothing about it.

The present is a time of change, and there are two reasons for that. In the first place, the war has brought about a shipping situation which is unprecedented in the history of the world. There is a demand for ships to-day such as never existed before, but there is at the same time just as real and as strong a demand for the men to run those ships. The heavy oil engine is one of the various possible ways of driving a ship, providing the ship be not too large. Its fuel economy is a direct value in ship operation, since it gives a larger cruising radius or the maximum possible cargo capacity. It, furthermore, is peculiarly adapted to a ship, in view of the fact that we are facing a labor shortage in ship operation, and the heavy oil engine ship can be operated with less men below the deck than any other type of vessel ever produced—except, of course, the small gasoline boat. The war, then, has brought to our attention this heavy oil engine as a possible motive power for the smaller of these new merchant vessels as well as naval vessels, tho more merchant than naval. And it is a fact that shipping people are considering this question to-day all over the country, but most of them are afraid to act. They would all like to, as near as I can find out by talking to them, but they are afraid to act. To my mind the time is not far distant when they will have to act, or lose something by not acting.

Aside from the shipping situation, there is another reason, and that is the economic reason of an appreciation of the value of this wonderful fuel that Nature has placed beneath our country's land surface. This fuel is peculiarly adapted to this sort of use: the generation of power in internal-combustion engines directly, with the highest possible efficiency and the least possible man attendance. Fuel has been wasted in this country, especially in that region near the oil fields, just because it was plentiful. Nevertheless, we are coming to the point when the people—if not the people, certainly the government—will be compelled to force the abandonment of the use of this fuel for all purposes where other kinds of fuel that can be had in more plentiful supplies would do as well. When you consider that oil or petroleum is the only kind of fuel that can be used in the high efficiency engine, then it becomes clear that to burn it to warm a living-room where charcoal or wood or coal of any grade would do quite as well is to commit a sort of economic crime. That feeling and the financial consequences of not acting upon the realization of that situation will come to a climax before very long, and result in a plan for conservation of our liquid fuel or petroleum supply, so that it shall be used for only those purposes for which it is peculiarly adapted and be barred from all other uses where other things will suffice. In the natural course of events people wait for prices to bring such a situation about, but this is not a time that properly is classifiable as belonging in the natural course of events. This is a time which is distinctly abnormal and unnatural. We hear every day plans proposed and turned down because there is no precedent, with always the rejoinder that here we are in a great war for which there is no precedent, so why follow precedents in other things? We have been forced to change in a thousand-and-one things, so let us change in a thousand-and-two things, and do it quickly.

I could expand to considerable length along the lines of the economic situation with regard to the use of oil and the peculiar adaptability of oil in the internal-combustion engine, and the particular adaptability of that class of engine to the ship service, but I want you to realize that there is another field also where there is a demand slowly but surely growing up, and that all these separate demands, coupled with the growing change in the economic situation, must certainly, one piling on top of the other, produce a new condition which I foresee.

We have a real gasoline automobile industry, and it is becoming a great manufacturing industry, but it is to-day tied up to and inherently dependent upon the lighter petroleum distillates. There is no highly economical gasoline or kerosene engine, and every reason leads us to believe fundamentally that none can be produced on the present system. To make our automobiles and motor trucks and tractors run, and to make our available sources of fuel supply last, there seems to be only one solution, and the leading engineers and mechanics in the automobile industry are beginning to talk about that solution: the adaptation of the heavy oil type of engine to the high-speed class of service which such as the automobile and the tractor require. It is coming; there can be no question about it. If anybody is able to-day to produce the high-speed type of engine necessary, even tho it costs more money to build, rest assured it will be adopted very quickly.

There is a third field, and that is the field of direct-connected electric generating sets. For a long time in the gas-engine business we built engines to drive generators in a kind of haphazard fashion. As time went on a particular type of outfit began to appear—a direct-connected, high-speed generating set, with engine and generator on one base, self-contained, the best example of which, on a small scale, is the Delco lighting outfit, which is being sold at the rate of over 50,000 sets a year now, all over the country districts. There are corresponding units of other designs in larger sizes. The fact that these sets are generally confined to gasoline limits their use, because in many places gasoline is unsafe to use; in other places it is not obtainable; in still others the cost of it is prohibitive. It is apparent that if we had the heavy oil engine adapted to that class of high-speed, multicylinder service, and with the necessary degree of regulation, it would open up still another field.

So in the field of application of the heavy oil engine I see just ready to be invaded these three things: First, a widened use for ships; second, a new use in the automobile type of motor; third, a corresponding new use for direct-connected, high-speed electric generating sets. Whether they be used on land or aboard ship, it does not matter. If they are designed right they are serviceable in either place.

It is of interest, and particularly pertinent here, to review some of the ideas that have been developed to date, and some of the suggestions available as lines of possible development in the direction of real progress. And this review I divide, for the purpose of clarification, into two topics—functional and structural.

Under the functional come all those questions connected with the supply of air, the supply of oil, the establishment of the proper relations between the oil and air to give the desired control of combustion after the necessary compression—in fact, all those physical processes involved directly in the development of the power within the cylinder.

Under the head of structural would come all those principles of type arrangements or typical part forms, and proper proportions of the metal structure that houses these physical processes and thereby produces a machine.

The first item under the functional discussion is that of charging the cylinder with air, and this is carried out by either the so-called and well-understood 4-cycle system of two valves per cylinder, or by any one of several 2-cycle schemes. Of the 2-cycle schemes there are a number. First we have the ordinary crank-case pre-compression chamber, which is barred from any engine of more than diminutive size, because the closing of the crank case prevents access to the working parts, in addition to imposing other bad conditions. The first step in avoiding the difficulties of the closed crank case which are prohibitive in any real engine comes when the connecting rod and crank shaft are left open and the front end of the cylinder closed, the front end acting as a pre-compression or air-charging chamber in conjunction with an air reservoir, which is necessary, so that the pressure in the front end of the cylinder cannot rise too high.

This front-end compression arrangement has certain faults that have led to the design and more wide use of others. For example, it is not possible in the oil engine of the 2-cycle sort, with the front-end pre-compression chamber, to put into the motor end a volume of air equal to the piston displacement: the volume must necessarily be less than the piston displacement measured at atmospheric pressure. That being the case, some of the burned gases or products of combustion cannot be expelled, and, at the same time, the residue is hotter than it otherwise would be. To correct that, the alternative schemes of a step piston or a separate scavenging pump have been developed, more particularly the latter. The step piston is the first of the scavenging schemes, and is a scavenging scheme because the volume swept thru by the step of the piston may be made larger than the volume swept thru by the motor piston proper, and the excess of this displacement is the scavenging displacement. By means of it more air can be put into the motor cylinder per charge than can possibly stay there at atmospheric pressure. This being the case, the burned gases may be more completely expelled, and, what is much more important, the residue of the gases left there would be much cooler before the next compression starts.

This step piston has certain faults of a structural nature which need not be detailed, but which are responsible for the wide use of the alternative scavenging scheme of a separate low-pressure compressor, built somewhat along the lines of the old-fashioned blowing engine. This arrangement is usually double-acting, so that one such scavenging pump will serve two single-acting 2-cycle motor cylinders. With it the 2-cycle engine can then be made to perform all the things that the 4-cycle engine can do, except as to the negative work involved in the pre-compression of that surplus air; so that, while the two engines may perform somewhat the same, the 2-cycle form will be necessarily less efficient by the lost or negative work, and, at the same time, some of the so-called simplicity of the 2-cycle engine has disappeared. So completely has it disappeared that it will be found that the weight per horsepower has grown in the 2-cycle to be substantially the same as the weight per horsepower in the 4-cycle. That is to say, when you start with the simple 2-cycle idea with the hope of getting half the weight per horsepower, because of twice the number of impulses from the same amount of metal, then you have to add this and that and the other thing, and by the time you have got thru adding enough to make it a real working engine the weights of both types are just about the same. Therefore the 2-cycle as compared with the 4-cycle, as to weight, might be called substantially equal. But there is an inequality in another direction. The 2-cycle, acting with more impulses per minute in the same volume, will run hotter and load the same sized bearings to a higher average bearing pressure, and, as a consequence, size for size, the 2-cycle will give more trouble with burnt pistons and overheated bearings than the corresponding 4-cycle. These are just a few of the reasons why this much-mooted question of 2-cycle *versus* 4-cycle as a means of air-charging remains a controversial matter rather than one of settled engineering practice. My own personal opinion about the matter is this: That in the smaller size, let us say up to 100 horsepower, or 200 horsepower maximum, the simpler form of 2-cycle, not with the separate scavenging pump, is a rather good thing and practical. In the next range of sizes, from, let us say, 500 horsepower, the 4-cycle works out best in the long run, and from that point up the pendulum swings the other way toward 2-cycle with scavenging pumps as matters stand to-day. But in the larger sizes the art is most undeveloped, and most of the uncertainty as to what is the proper engineering practice concentrates right there.

The next item under the functional discussion is the introduction of the oil, to form either an explosive mixture for explosive combustion or to prevent the forming of an explosive mixture so that the oil may burn non-explosively. Before examining the means of introducing and controlling combustion of the oil, I want to point out the fundamental and controlling value of a compression before injection on the one hand, and of the rate of oil burning following the right amount of compression, on the other. Consider the former point first. It can be demonstrated, and it is pretty generally understood now without demonstration, that, other things being equal, the more the air charge is compressed before the introduction of the oil the higher the mean effective pressure will be; and that, of course, is a prime factor in power and, at the same time, the higher the efficiency, or smaller the fuel consumption. It may therefore be said with practically no reservation that in an oil engine as much compression should be carried as is possible. But that is not all. After the compression has been completed, the oil must be introduced either at that time or just previously, so as to produce a suitable and proper combustion line of one of the two characteristic types or mixed.

The two characteristic types of combustion line are, first, the vertical combustion line produced by an explosive mixture, and, second, the horizontal combustion line produced by a gradual introduction of the oil, the oil burning as it comes in, and which latter system has been called the Diesel system. It is clear, of course, that we might burn part of the oil explosively, raising the pressure a fraction of the maximum, and burn the rest non-explosively, without further change of pressure. Or we might have such a slow introduction of oil as to cause the combustion line to drop as the piston moves out on the working stroke. The two types of combustion line are (*a*) the vertical explosive, and (*b*) the horizontal non-explosive, or Diesel, forms. Now, of these two methods of oil combustion as to rate, which should one choose? That question should be settled before considering the means of introducing the oil, because one is not warranted in spending time in determining how to introduce the oil until there is first a decision as to what end is to be accomplished by it. In other words, we must establish the specifications before undertaking construction.

It will be found, by comparing the full diagrams for those two combustion lines, with the same amount of oil and expansion, of course, following both, that about the same mean effective pressure is possible with both or with either. That is to say, so far as power is concerned, there is no choice. But, on the other hand, when you compare efficiency or fuel consumption, then this startling fact comes out: That the constant-pressure or Diesel kind of non-explosive combustion is capable of only half the efficiency of the other kind of combustion, the explosive sort. To put it a little differently and more precisely: If the fuel be burned explosively after compression, then an efficiency can be produced with a corresponding fuel consumption equal to that obtainable with the non-explosive Diesel combustion when the latter has twice the compression of the former. Again, to put it in still another form: A Diesel diagram with nearly 500 pounds compression produces no better efficiency or fuel consumption than an Otto cycle diagram with 250 pounds compression. There is therefore absolutely no doubt on fundamental ground as to which of these two possible modes of burning offers the best promise of results. They are equal in power possibilities and nearly two to one in efficiency with reference to compression. When I say the latter, do not misunderstand. Do not think I mean to assert that the Otto can give and always will give twice the efficiency of the Diesel—not at all. They can be made exactly equal in efficiencies and fuel consumptions with selective compressions, but when the compression is thus selected to do that thing it will require twice the compression with the Diesel as will be required with the Otto arrangement.

This is particularly interesting when you consider that fully 90 per cent. of all the development work that has been done with this heavy oil engine has been done with the less promising Diesel cycle, and the very promising Otto cycle has been almost entirely neglected. I say it has been neglected, and yet I do not mean that. It has not been neglected by those people who understood the possibilities—the students of this subject. It has not attained the popularity or the standing in a commercial way of the Diesel.

In this functional study the next important consideration is the compression itself, and the relation between the degree of compression and the mode of combustion, or control of combustion. The oil has to be ignited, and there are various ways of igniting it. It must not, however, be ignited until the right time comes; that is, not until a sufficient degree of compression has been executed—whatever is desired. Therefore there must be an igniter, and the ignition, as a process, must be under control. Now, the ignition will always take place whenever any fuel in contact with air reaches the ignition temperature. The air under compression is rising in temperature and is approaching or passing the ignition temperature in that process of compression. Somewhere or another in the process of compression, if it be carried far enough, ignition temperature will be established, and ignition will inevitably occur, if there is any oil in contact with the air.

It is therefore essential, in considering the limit of compression in its relation to the introduction of oil, to have some kind of mental picture, and preferably exact figures, as to the way in which the temperature rises in compression, especially with reference to the ignition temperature as a basis of reference.

The ignition temperature of these heavy oils is a somewhat uncertain physical constant, but from my experience I am inclined to think this is very close to 950° F., or near enough to that for practical purposes.

To bring this matter before you I have prepared a little table here (see accompanying table). This table shows at the left, first column, initial air temperatures of from 200° F. to 600° F. before compression. Starting with these temperatures, then, to reach ignition temperature it would be necessary to have the compressions, indicated in columns two and three. To reach temperature of 200° less than ignition temperature the compression would be as shown in Columns 3 and 4. To reach a temperature of 200° F. over ignition temperature the compressions required are shown in Columns 5 and 6. Or, for 400° F. over ignition temperature, the compressions of Columns 7 and 8.

To explain further, starting with atmospheric air at a temperature of, say, 70° F. in an engine-room, it is drawn into a cylinder, and is bound to become somewhat heated on its way. It will become heated by contact with the hot intake ports, sweeping over the intake valves, sweeping against the interior cylinder walls, which are very hot, especially in large engines with thick metal, and finally it mixes inside with the hot products of combustion from the previous shot. So, to say that this 70° F. air will rise 130° F. and have a temperature, therefore, of 200° when compression starts is a very moderate estimate. It is never less than that, and that is the reason I have made this the minimum figure. It might easily be much more than that, especially when it is considered that in some of these engines the interior is red hot in spots. In some of them the whole wall, especially the hot bulb type, is deliberately kept red hot as an igniter. It is quite clear that any products of combustion or air in contact with that red-hot spot might easily approach or exceed a temperature of 600° before any compressing is done at all. So I make the temperatures before compression range anywhere from 200° to 600°, and there is even justification for going further.

Compression vs. Initial Temperature vs. Ignition Temperature (*)

Initial temperature	Compression Lbs., Sq. In. above atm. (14.7) with 0.1 pound valve drop							
	Ignition temperature of 950° F.		200° F. below ignition		200° F. above ignition		400° F. above ignition	
	Min.	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*
200	190	293	104	152	305	511	467	800
300	110	155	58	79	181	279	282	460
400	67	92	34	42	114	165	175	275
500	41	52	18	22	75	101	118	174
600	23	31	8	10	47	63	79	107

Based on $S = \begin{Bmatrix}1.33\\1.40\end{Bmatrix}$ in. $\quad P = 14.6\left[\left(\frac{T\text{ final}}{T\text{ initial}}\right)^{\frac{S}{S-1}} - 1\right]$

Now, when the compression starts the pressure follows the general law given at the bottom of the table, and from that certain variations follow; but we are not quite sure as to what value the exponent S has, altho we do know it cannot be larger than 1.4. We know by experience it is not less than 1.33. So, for each one of these values I have calculated two figures—the compression pressure in pounds per square inch above the atmosphere—and you see here that to reach ignition temperature with 200° initial temperature would require 190 pounds compression minimum to 293 pounds maximum—actually somewhere between; it is difficult to fix it any closer. Whereas, if the initial temperature was 600°, then the ignition temperature would be reached in that same cylinder with a compression of only 23 pounds to 31 pounds. That brings out in the most striking fashion this fact: That if the fuel is in contact with the air in the cylinder during compression, then the amount of compression cannot be very large in any case without producing an uncontrolled preignition. And, more important still, if any part of the oil and air is very warm before compression starts, then practically no compression can be carried at all. And, if you cannot carry much compression, then you have a very high fuel consumption and a very low efficiency. An engine carrying such low compressions as are here required would burn nearly two pounds of oil per hour per horsepower, whereas the best engines are to-day running on about four-tenths of a pound—a ratio of five to one.

Now, suppose an igniter that was itself under control, and fuel in contact with the air in the cylinder. How much can we compress it without any danger of preigniting it, so that when we want to fire it can be fired with the igniter that is under control? I suggest that 200° margin is about as good as can be estimated. Let us limit the final compression temperature to something like 200° under the ignition temperature, in which case these are the allowable compressions: With 600° initial temperature, the final compression pressure is eight to ten pounds; with 200° initial temperature, 104 to 152 pounds (see table).

On the other hand, suppose that the system was such as the Diesel, where the air temperature itself is to serve as the igniter. In that case, to insure ignition, we should have a margin of about 200° in the other direction; that is to say, the air should be compressed to a sufficiently high pressure not only to produce ignition temperature, but 200° more, in which case the last two columns give the compressions that are necessary. Should the oil now be introduced into the cylinder by means of compressed air to make a fine spray and scatter it thru the charge of air, in accordance with the general practice, then it must be remembered that this air jet which is doing the spraying and the scattering is itself exerting a cooling action. Consider 1000 or 1200 pounds air expanding thru the spray valve into a cylinder with about 300 or 400 or 500 pounds compression pressure, and it can readily be seen that there is a very considerable cooling action right at the jet. That it will act to prevent ignition, and, to make sure that the oil will ignite in spite of such cooling influence at the point of oil injection, it is necessary to carry the compression still higher. Let us provide at least 400° over ignition temperature, in which case with an initial temperature of 200° we would require something between 467 and 800 pounds compression. With 600° initial temperature we could secure this 400° above ignition with anywhere between 80 and 100 pounds compression.

These figures should be made the subject of some study and be used in considering the various structural arrangements, because in them will be found a key to the question: Why cannot this type of engine—this arrangement—be efficient? And why is the other arrangement highly efficient? Here also will be found the key to the question of how we should proceed to make the less efficient one more efficient. These three elements stand out:

First, is the fuel in contact with the air during compression, or is it not?

Second, if the oil is in contact with the air during compression, is the region of contact all of low temperature, all of high temperature, or any part of it a high temperature region when the compression starts? The initial temperatnre has a great effect on the degree of compression needed or permissible.

Third, if the oil is not in contact with the air during compression, but has to be introduced subsequently, how should it be introduced with reference to the igniter? If the air itself is to be the igniter, then a certain high value of the compression must be obtained, or the engine will not run. If the air itself is not to be the igniter, then what kind of an igniter can we provide? We will look into that question.

All the first oil engines to attain commercial success had vaporizers. That is to say, there was some element, the duty of which was to heat the oil alone for later air mixing, or to heat the oil and air together, to produce a vapor air mixture. It matters very little as to what were the details of those arrangements—whether one produced a heavy carbonizing action and another one did not. They are all one as regards this point of controlling importance: The mixture when formed by any such vaporizing system is necessarily a warm or a hot mixture. Just how hot it has to be depends upon the vapor pressure of the particular oil, or rather the heaviest constituent of that particular oil, and I will give some figures to make it clear. A 60° Baumé gasoline vaporizing in air requires a temperature of about 100° to 110°. The ordinary lamp kerosene of 150 flash point vaporizing in air requires a temperature of 250. A navy fuel oil vaporizing in air requires a temperature of 420, and so on. One could go on with any grade of oil or residue; for each there is some temperature at which the vapor of the oil can be produced in the right proportions for combustion and in contact with its air, without residue and dry. The heavier the oil the lower its vapor pressure or that of its heaviest constituent, then the hotter that mixture must be to be a gaseous mixture; and the hotter it is, according to this table, the lower the compression it can stand without self-igniting. Therefore only those fuels that have high vapor pressures or that can make cold gaseous mixtures can be treated with the whole mass under compression. Those oils which are within the heavy class of oils, and have so low a vapor pressure as to require 300° or 400° initial temperature outside the engine plus a couple of hundred degrees rise in temperature coming into the cylinder, can be compressed hardly at all. Therefore such heavy oil engines cannot by any possible conformity with Nature's laws be efficient. It is fundamentally sound that all those schemes for heavy oil engines that involve vaporizers are utterly incapable of producing an efficient engine.

For some reason or other everybody playing with this class of machine in the early days seems to have been absorbed with the idea of cooking the oil; they seemed to feel that it had to be roasted to death, and then wondered why they could not carry any compression, and why the efficiency was so low and the fuel consumption so high. This fundamental impossibility, against which mechanical ingenuity is absolutely helpless, never hit them at all; and that situation has lasted from the early '70's up till to-day, and people are still inventing schemes of this kind.

It is perfectly clear that to produce a high efficiency, and at the same time a fairly high mean effective pressure in the interest of high power, the first and fundamental requirement is not only high compression, but to keep the oil away from the air until the time comes to burn it. By keeping the oil away from the air during compression any compression you please is yours for the asking. It is purely a matter of mechanical clearance between the piston and cylinder head. Therefore it would seem possible to secure almost any efficiency in such an engine with the delayed introduction of oil under the system which has received the name—and a very good name—of late-injections engines. Late injection is fundamental to efficiency. I will not say there is no limit to the efficiency, but it is far beyond the common old practice when this principle is adhered to.

Now the late-injection principle of working is highly developed mechanically only in Diesel engines, and therein you see there is a little scientific engineering anomaly. The desired and necessary principle of high compression with delayed injection has been developed in its application to the less promising type of cycle—the Diesel; and the more promising type of cycle, the Otto—that which promises a given fuel consumption with half the compression of the Diesel—has been delayed; so that our engines have been highly developed along the less promising line without scarcely any development at all along the more promising line. Do you wonder, then, that with the success we have had with the less promising we may expect and look forward to much greater success with the more promising field when it is vigorously followed up?

We have come now to this point: That after compression we are to introduce the oil, and the oil may be introduced in such a way as to produce an explosion or to burn at substantially constant pressure without explosion. I want to point out to you next the controlling means in use for doing either one of those things or both of them.

First, as to the Diesel: At the time the oil is introduced the temperature of the air is something higher than the ignition temperature—200°, 300°, 400°, or 500° higher than ignition temperature—and so far in all these engines the oil has been introduced and sprayed by the aid of compressed air. How is the feed of oil controlled so that the rate of combustion shall be just enough to prevent the pressure falling along the re-expansion line, but kept substantially constant? That is entirely a matter of spray-valve design. If you set yourself the problem—especially those of you who have not worked on this problem—of designing a scheme to squirt oil into a cylinder against 400 or 500 pounds compression pressure at a graduated rate for 10 per cent. to 15 per cent. of the stroke, so as to hold the pressure constant, the oil burning as fast as it enters, you will find some little problem on your hands, and I venture to say that eight out of ten men will start with some kind of cam-driven pump. Now, that will not work at all. The thing that is relied upon is the tendency of the oil to stick to a metal plate. To make that clear, consider the ordinary spray Diesel valve with a fairly heavy stem in a casing. Beyond it there is a graduated orifice outlet, which is the spray orifice and is changeable in size to suit the viscosity of the oil. The oil is pumped into the chamber or space between the casing and the valve stem by a pump which has only one duty to perform, and that is, measure the amount, not time or graduate of the injection. That cannot be done—or it never has been done. I do not think it can be done. The oil, in the ordinary course of events, is put into the spray-valve chamber before the injection is wanted, and it will run down to the bottom more or less fast. If the valve be lifted and the oil itself has reached the bottom or valve seat, the first thing to happen after the opening of the valve is a squirt of solid oil with no spraying whatever. In an instant the oil is all out, and, instead of maintaining a graduated combustion for 15 per cent. of the stroke, we have a lump of oil squirted in without spraying or graduation. There will be a certain amount of combustion, but only part will burn; the rest makes a little lump of carbon.

Now, to secure graduation of oil feed, all that has been done is to stick a lot of plates with holes in them in the space between valve stem and casing. These plates have definite thickness spacing and drilling; sometimes they are given special forms and surface finish, each designer adopting an air of great mystery about his arrangement, and claiming absurd superiority over his rivals.

All that these things do in the oil chamber is to provide an extended surface to which the oil naturally tends to stick. It might be filled with shot and it would no doubt work just the same. The oil is pumped into this chamber and when the valve is pulled open the oil tends to travel down, partly by gravity and partly by the surface frictional influence of the air on the oil. The oil, however, is sticking to that labyrinth surface. The oil chamber is nothing but a mechanical labyrinth. That is what it is called for want of a better name. And that is the only means that works as a graduater of oil feed, except one. The other one surrounds the stem valve by a sort of Venturi tube casing, between which and the valve body is found the oil-receiving chamber. There are two holes in the Venturi partition between the oil chamber and steam chamber, one from the Venturi throat to the bottom of the oil, the other imposing the total air pressure on the oil surface. When the valve is open the compressed air flowing thru impinges on that hole to the surface of the oil and builds up its total pressure, while at the same time the other hole, being at the throat of the Venturi, is subjected to a lesser pressure by the air velocity head, thus developing lifting tendency on the oil, and we have a regular vacuum flow injector. This action of the former one of the labyrinth forms the basis of all the schemes for graduations of feed of oil from the spray-valve body to the spray-valve nozzle, so that the oil feeds during the required period of time at a more or less steady rate to this nozzle, and it is torn to pieces or sprayed by the velocity of the air issuing from it. It is clear that with this arrangement the rate of oil flow, the time of oil feed, and the rate of combustion will vary with the viscosity of the oil.

Should such a valve be adjusted by the spaces and orifice size to give the required feed for a given oil, and then supply an oil of lesser viscosity, or maybe the same oil supplied hotter, or really a less viscous oil, then it will discharge much more rapidly, and instead of a horizontal combustion line there will be a rapid rise of pressure somewhat like a slow explosion. This indicates what is necessary if we desire to make a spray nozzle suitable for producing an explosion. To produce the explosive mixture and secure explosive combustion of oil with the spray nozzle, the first step necessary is to reduce the flow resistance in the body of the nozzle by removing a considerable amount of the labyrinth surfaces or by reducing the viscosity of the oil by heating it. As a result the oil will be discharged much more rapidly, and if enough resistance be removed from such a spray nozzle it would give a substantially instantaneous injection of oil as a liquid spray. If that occurred we would have a more or less finely divided spray scattered thru the mass of compressed air, and if the air is not up to ignition temperature, then we would have produced what might be called a liquid explosive mixture, ready for any kind of ignition that is handy. It is a liquid explosive mixture because no attempt has been made to vaporize the oil. All that has been done is to make really fine fog of liquid drops suspended in the air, scattered thru the combustion chamber. To get such an explosive mixture or charge ready for ignition it is necessary that no part of the interior walls or the air itself touched by the oil be up to ignition temperature, because if the air should be up to ignition temperature, as would be the case with the Diesel, then the oil would ignite as it came in, before the oil spray charge was scattered thru the air. To obtain the explosion it is necessary to get all the fuel into the cylinder and scattered thru the air before it is ignited, just as with delay electric ignition. On the more desirable Otto cycle with its explosion it is necessary to prevent the air reaching ignition temperature during compression; it must be incapable of igniting the oil, and the ignition, by whatever means is relied upon, must itself be delayed long enough to let the whole charge of oil get in the cylinder, because unless it is in there is nothing that can explode.

Now as to igniters: The common thing has been a hot plate; sometimes a bulb of spherical form with a neck; sometimes a hemispherical bulb without any neck, just forming a cylinder head; and sometimes all sorts of weird curves and twists and shapes—every one of them the subject of a patent. Now, of that collection, what is good and what is bad? There is a simple way of sizing it up. The hot metal—that is, the igniter—must be so related in position to the injection point that no part of the oil reaches the hot plate before all of it is in the cylinder, and the shape such that no part of the oil reaches the hot plate before any other part.

Let me illustrate and you will see the force of this principle. Consider a cylinder with a spray valve at one edge of a nice hemispherical plate, red hot, the oil being sprayed at an angle toward the plate. There have been many made like that. The hot plate comes up quite close to the injector, which discharged a more or less conical spray. Some of the oil will strike the hot plate before the oil is all in the cylinder and considerable of the air. The first oil that hits that plate is going to fire the charge, or so much as has entered, and much of the air is utterly inactive and cannot do anything, as it has received no oil. At the same time, an explosion of part of the charge has taken place and the rest is still coming in. What does it meet on the way in? A red-hot—yes, a white-hot—mass of inert gas. What will happen? Nothing but crack, liberating free carbon and carbon monoxide. The unused and unmixed air leaves free oxygen in the exhaust, and with it the unburned fuel appears as carbon monoxide and much free carbon with plenty of solid carbon cake inside. A very low mean effective pressure and low efficiency will result, and the engine will be very dirty.

The ideal condition is that in which no part of the oil strikes the igniter sooner than any other part and none of the oil strikes the hot plate until all the oil is in. Now, what kind of arrangement would give that? Suppose we had a spray valve making a cone-like spray discharging axially into a hemispherical head, the center of which is the spray orifice. Then at the time the oil at full load had reached this hot ignition plate the last oil would have come in if the dimensions were right. That would be in conformity with the principle laid down. That arrangement will give anywhere from 50 to 100 per cent. more mean effective pressure than the non-symmetrical arrangement previously described, and with it any compression you please may be carried. It does not matter how hot that latter plate gets, whereas the former has to be run cool on the side where the oil first strikes and yet hot enough elsewhere not to miss fire. At full load it tends to get too hot and pre-ignite and knock its head off; with a light load it fails to get hot and fails to fire at all. And so the engines in that class are always provided with some kind of scheme to prevent getting too hot at heavy load and too cold at low load. The popular water-injection scheme usually does nothing but wash the lubricating oil off the cylinder wall.

For a long time, practically thruout the whole history of this art, this condition of necessary relation between the spray valve and the hot-plate igniter has not been realized, and yet hot-plate igniters have been in almost universal use. Now hot-plate igniters themselves are a bar to progress, because if we use a hot-plate igniter it has to be an outer wall. It has to be an outer wall so that you can start it with a torch and still not burn up. An inner wall cannot be started. A hot plate submerged in a cylinder cannot be started, because you cannot get a torch at it from the outside. If a hot-tube igniter be provided for starting and an internal plate relied upon for running, as is sometimes done, then you have no control over that hot plate at all and it will burn out. So a hot-plate igniter has to be an outer wall to be practical, and when you have made it an outer wall to be practical, then it is not really practical, because it limits the size. That red-hot plate lacks tensile strength. To be sure, a selected grade of cast-iron can be found that will not lose too much tensile strength, but nevertheless it is very weak in proportion to what it might be. As cylinder sizes go up—and I have already indicated that one of the great fields of need for the heavy oil engine is ship work, which calls for cylinders to go up just as high as we can make them go—then the external hot plate is barred. It is not good because it is too weak structurally. Here is the place, then, where the functional problem leads to a structural debarment and where progress into the larger sizes requires an abandonment of the red-hot plate as an igniter—or at least a very material modification. If we can get along without it at all, then we need not fool with modifications, and as a result of that thought many people have tried various other schemes, and there is now being attained some success with electric igniters and with moderately warmed internal hot plates, which are more properly called " warm " plates. Suppose, with reference to the latter, that we have a 300° internal temperature and one would stop just short of ignition. Suppose we had a 300° initial temperature; then for practical reasons about 279 pounds compression (see table) would carry the entire air above ignition temperature 200°, and that would not be practical with late injection. If, however, the initial temperature of the air were lower, or a sufficiently lower compression were selected, we could come within 100° or 200° of ignition temperature and still have a very substantial compression. As a matter of fact, it is perfectly feasible to use compressions up to 175, approaching 200 pounds—possibly more—without reaching ignition temperature, provided the initial air is not too warm. Suppose we were injecting straight toward the piston and we had a spot of metal on there that did not get red hot, but raised the temperature of the air right next to it 200° or 300° higher than elsewhere. That is all that is necessary for ignition, and that is one way the thing might be done. A cold external wall for strength, a warm internal spot at the maximum distance from the igniter, not red hot but sufficiently warm to supply a couple of hundred degrees difference between the temperature attained by compression (which is not high enough to produce ignition) and the amount necessary to actually produce ignition at that one spot alone.

We do not know much as yet about that scheme, except it is possible to run that way. Whether it can be developed into a practical controllable thing remains to be seen. I am inclined to think it can. If it can, then one serious bar to the increase in size and more extended use of the Otto cycle engine has been removed and a new field of most interesting and valuable possibilities opened up.

Without that, however, there is still another way of proceeding that is receiving some attention. For a long time back it has been known that with a sufficiently fine and proper kind of spray of oil into air an ordinary spark plug would serve as an igniter. With the wrong kind of spray and plug the oil would collect at the spark plug and short-circuit it, but a spark plug can be made to ignite the right kind of spray just as positively as it ignites a gaseous mixture. An apparatus involving the lighting of sprays by spark plugs is going to receive considerable impetus in the near future.

As to engine schemes: Suppose we had a thoroly cold interior engine—an engine the walls of which were all cold, just as cold as we can get them, and to my mind you cannot get them cold enough for a good practical oil engine—the colder the better. Into that cold cylinder we admit a charge of air and compress it, but not sufficiently to produce ignition, and when we get a sufficient compression to produce a highly economical engine as to oil and sufficient to produce a mean effective pressure approaching 100 pounds per square inch, then ignite with this spark plug. That can be done, and it is a most interesting possibility. It is particularly interesting because in conjunction with it it is possible to use a modified oil spray.

With the standard Diesel engine the oil-spray valve is supplied with compressed air under a thousand pounds and more. Now, in the actual running of these engines the air compressor to supply that air and the air storage are just about as big a nuisance as the engine—sometimes, in fact, and often, more. If we could get rid of that, it would be a splendid thing to do. A " solid " spray is therefore a highly desirable thing.

So far we have succeeded in making a number of engine solid-spray valves that work quite well, and they work so well that I feel confident that the end of the compressed-air spray is drawing near, and that thereby we are going to eliminate another big source of trouble. I am not sure that the solid injection spray I have in mind will work on the Diesel engine, because the Diesel engine requires a graduated feed, and I am not at all sure that the principle of action of the solid spray can be adapted to the graduated feed. It works splendidly with the instantaneous feed for the Otto cycle or explosion engine. There is only one principle that need be kept in mind to explain the many ways of working out the solid spray, and that principle is pretty old. It is the principle of the navy fuel oil-burning spray for boilers. The navy and other ships cannot afford to use compressed air or steam for spraying oil, as is so common on land, because they have not the fresh water with which to produce this steam. They are therefore compelled to use a mechanical spray, and this type of spray has been very highly developed. It involves nothing more than a minute orifice from which the oil is discharged with a combined motion axially thru the hole and rotary as it comes out, the rotary motion being developed before the oil reaches the hole in a rifling tube or tangential feed passage to a little whirl-chamber just back of the spray orifice. By giving the oil a whirl behind the spray orifice with a proper exit from the orifice it issues with a motion in two directions—axial and rotary—producing a sort of solid conical spray that is fine and works well in an engine. By making the passages small enough in such a spray valve so that they are practically capillary, then a direct-acting pump plunger slamming against the solid column of oil will make such a spray without any dribble at the ends of the spray period. Remember that no dribble at the end or beginning of a spray is permissible, because every drop that dribbles carbonizes. To avoid the dribble the only thing necessary is to get the passages substantially capillary in size, and that is not difficult. At first glance it would seem as if that boiler spray valve could not be made to work with rapid intermittence, but it can and is so working to-day.

Now a word or two on the structural side. We may assume that this functional question has in it considerable undeveloped possibilities, and that these are not mysteries, but are lines of purely rational progress, the key to which we have in every instance, and nothing is unknown except how far you can go. We know the route every time; but we do not know how far we can go. Assuming that you can see with me in your mind's eye non-Diesel, late-injection, high-efficiency oil engines working as well as the Diesel—or better—then arises the question, How should the structure be built? Are there any lines of standardization that can be well and properly applied there? Or is every designer to regard himself as the one selected by the Almighty to produce something that no one else ever made? For some strange reason, that seems to be in the minds of almost all oil engine designers. While for years we have been building shafts, frames, and engine structures for steam engines and similar structures for pumps and compressors, just as soon as an oil engine designer gets his hand over a drawing-board he wants to throw all that experience away and get up some other thing and make more trouble than do the parts that are peculiar to the oil engine.

The point of view to take with regard to this structure is this: There is no essential difference in kind, except the cooling problem, between an oil-engine cylinder and a steam-engine cylinder. The difference is one of degree in the structural problem. There is no essential difference, certainly none in kind, between the problem of the frame and the bed plate and the rest of the running gear of the oil as compared with the steam engine. That being the case, these queer arrangements that have crept into the oil-engine field and that have become more or less standard there, quite contradicting all previous experience and established custom with the more firmly established steam engine, cannot be accepted. There is no difference whatever in the design of a column to support a bridge, a pier, or a building, or to support a statue; all that counts is the load to be placed on it. And yet the oil man has persisted in carrying out his structure from cylinder down to bed plate on radically different lines than have long been standard with steam. The result is hopelessly bad. Let us bring out some of our good old designers who understand the designing and building of structures to carry loads, and I would not tell them anything about the oil-engine peculiarities at all. Some other man is taking care of that. Then we will get somewhere.

Just to point out one or two things, to illustrate what I have in mind, consider the most widely used Diesel cast-frame structure extending from bed plate to cylinder head, and being an axially expanding cylinder line. This cylinder line is a stressed member, the stress being bursting stress, with 400 or 500 pounds per square inch normal pressure at the top, and possibly an accidental maximum pressure with a pre-ignition pressure of twice that amount—1000 or 1200 pounds per square inch. Now we certainly know how to build cylinders to withstand bursting, so this is not peculiarly an oil-engine problem, except that its expansion must not be restrained. That cylinder structure is inside of a heavy casting and held at the top. This casting is practically an "A" frame with a cylindrical extension at the top; the cylindrical extension forms the water-jacket and is faced at the top on which the cylinder line flange rests. There is a slip joint at the other end of the line to allow of longitudinal expansion of the cylinder line barrel with reference to the jacketed frame. An engine built along such lines as that is fundamentally wrong, because the jacket is at the same time a frame. What is its principal duty? Its principal duty is to hold water—and anything that will hold water will do just as well—and yet you will find big engines with jacket walls of 1¼-inch cast-iron for many feet in diameter. Think of all the weight that goes with that, and for what? To hold water and transmit an upward tension load from the cylinder head down to the main bearing. Nothing could be more fundamentally wrong. In the first place, as to the material: It is all cast-iron and is always in tension if it is loaded at all. If it were a steam engine there would be an alternate compression and tension; but here it is tension-loaded, and if there is any worse material than cast-iron for carrying a tension load, it is probably cast aluminum. Furthermore, if such a cylinder line barrel is strong enough to resist bursting, it has just twice the factor of safety for the longitudinal tension stress, which means that the double metal of line and jacket is entirely unjustified. The cylinder should be held to the frame at its crank end and the jacket eliminated as a stressed member. There is no reason for carrying a heavy cast-iron wall for a jacket, when ordinary tank steel will do the job just as well and a little bit better. We have oxygen welding apparatus that will enable us to weld the edge of a thin sheet to cast-iron with perfect success and with not much expense.

There is then a necessity for changing the cylinder to take off that unnecessary weight. Do you know that some of these engines of stationary form—the class I am condemning—weigh 600 pounds per horsepower? Think of it! And when these same engines are refined down for ship work without changing the type of structure, just the same typical arrangement, but reducing the bed plate and getting rid of fly-wheels, they come down to about 150 pounds per horsepower. But there they stick. To go below that it is necessary to change the structural arrangement to conform more and more nearly to the better and more refined class of standard steam practice, and in this country there are excellent models for them, and all that has to be done is to follow them out and keep within the same method of calculating loads and factors of safety—keep the same factors and the resulting work just as well as in the steel. That means not only the taking away of this cast jacket and making the cylinder barrel carry the two kinds of stress—the bursting and the longitudinal at the same time, which it is perfectly able to do—but it means also to take this heavy cast-iron frame structure away from the space between the cylinder end and the bed plate and to substitute for it the steel tension rod construction of the torpedo boat or yacht engine—to mention the two most highly developed forms of that structure. To be sure, that type of engine is not a stiff engine. Certainly the cylinders are going to sway and weave. But what of that? Where did these oil-engine designers get the idea that this thing had to be a stiff structure, like a brick wall? I do not know where, but they got it, and there it sticks.

The most successful engines we have to-day, and the most wonderful machines that we have ever designed, are steam locomotives. When you consider what they have to do and how well they do it, they are truly wonderful. What would happen to a locomotive that was built stiff? And what would happen to the rails on which it runs? You would have neither locomotive nor rails at the end of the first run. The steam engine that gives years and years of service and is regarded as a model of reliability, carrying a ship trip after trip, back and forth across the ocean like a ferryboat—is that a stiff structure? It is not; it weaves and twists, but that does not hurt it. Why, then, should we insist upon the cast-iron stiff structure for oil engines? There is no reason on earth why we should. So I say that we can take the steam-engine structure from bed plate to cylinder and design and apply it to oil engines, selecting dimensions to give similar elastic factors, bearing loads, and so forth, and it should give equal success.

After these two changes it will be time to remove the outside cast wall of the cylinder head. By taking the cast head jacket away from the top of the head we will free the valve housings, the intake and exhaust ports, the housing for spray valve and starting valve. These will then be exposed and the present elaborately cored casting eliminated. These cored heads are so awful the foundrymen and moulders are not to be blamed for doing with them what they always do when they get into a corner with cores that are too intricate—they knock a piece off; and then we wonder why the head overheats. The designer thought he had provided for water, but the moulder could not get it there, and the designer is responsible for asking a moulder to do what no man could do. In proportion as that casting is made easy to mould, so it will be a good job. By means of the oxygen weld the whole cylinder head top can be left off and the only cores left are the cores for the intake and exhaust, which are easy cores. Then you get a clean casting which can be inspected on both sides and free of bad shrinkage stresses, add a sheet jacket welded around the edges, and you will have a real job.

Just as an indication of what happens when this thing is carried out, even in part, I will tell you that the most highly-developed of these oil engines to-day are the submarine engines. In those engines the heavy cast frame structure in the better of them has been removed, and, as a consequence of the steam-engine practice as to frame structure, those engines which in the older form of oil-engine structure weighed 150 pounds, more or less, to the horsepower have come down to what? Thirty-five or forty pounds per horsepower. They still, however, are carrying the cast-iron jacket and a cast-iron roof to the head, so there is room for saving some more without doing any harm whatever.

To conclude, then, with a word or two about the auxiliaries—especially with ships, because you may get a perfectly fine engine, and by wrong kinds of auxiliaries or wrong arrangement of auxiliaries have an awful hard engine-room to work. The tendency for some time has been to regard the engine structure, when it comes to auxiliaries, as a sort of Christmas tree on which you hang anything you want to use. If they decided to put a fire-alarm in the engine-room, I have no doubt that they would stick it on the engine somewhere. You find circulating pumps, air compressors, water pumps for circulating water, and oil pumps, in some cases bilge pumps—all hooked on to the main structure of the engine, which, in some cases and quite a number, is 2-cycle, with a row of scavenging cylinders stuck along one side, so that they resemble the old river boat engines. It certainly makes a weird combination, and in the old-day steam-engine practice just that thing was done. They carried feed pumps on the engine, condensers were mounted on the engine, and hot, well, and circulating pumps likewise. It took us 150 years to get rid of that arrangement, and it is no longer standard practice. The engine structure should be preserved and respected as an engine structure, and not interfered with at all by hanging any kind of trimmings on it that have the slightest possibility of interfering with access to the engine. Doubly so is that true when the auxiliary attached to the engine does not and cannot behave right as attached.

In the latter connection I would call your attention particularly to the circulating pump for water. When the circulating pump for water is driven off the engine,

(Continued on Page 297)

THE INCOME TAX†

AN ENGINEER'S ANALYSIS WITH SUGGESTIONS

By CARL G. BARTH, Member

PART 1

ONE morning in August last my eyes chanced to light on a telegram from Washington that appeared in the *Chicago Herald*, and which gave the status at that time, in the Senate Finance Committee, of the personal income tax law. After much controversy in the joint committee of the House and Senate (with some modifications) this was finally, in October last, enacted into the present personal income tax law.

In that telegram reference was made only to the incomes to be taxed at various rates, or, in other words, to the purely mathematical features of the law, and to this alone my considerations will be strictly confined. Not that I do not feel both competent and justified in criticising adversely some of the other aspects of the law, such as the special discriminatory 8 per cent. tax on incomes of professional men and women in excess of $6000; the insignificant proportional difference between the tax imposed on single and married men enjoying large incomes; the determination of a man's status as single or married for the year 1917, for the purpose of the tax, by his status in this respect on December 31 only, etc. As there are thousands of persons far more competent to criticise the law in its broader financial and economic aspects, I shall humbly confine myself to that part for which a natural inclination and a wide experience in applying a limited knowledge of mathematics to practical engineering problems have perhaps especially fitted me.

What arrested my attention in that little notice in the *Chicago Herald* was the absolute lack of mathematical regularity in the increases at which incomes are taxed with increasing tax rates, as well as the similar lack of regularity in the tax rates themselves; while the very term, "a graded or graduated tax," as applied to the law, would seem to imply a tax or tax rate that would gradually increase with the increase in income according to some law, which thus, dealing with numerical values or quantities, would be expressible as a mathematical formula giving either the tax or the net tax rate to be levied on any particular income, in terms of that income.

In this lack of regularity is immediately recognized the lack of an experienced mathematical mind behind the whole arrangement, and I went at once to work to investigate the whole matter in the same way that I am used to investigate practical engineering problems, confident that such investigation would yield interesting and useful results.*

A summary of these is:

1. A mathematical formula for the tax on married men, which gives directly the tax to be levied on any income, and which averages the tax imposed by the present law to such an extent that it agrees perfectly with the law at no less than four particular incomes and within 0.16 of 1 per cent. for a fifth income; and, finally, within 0.5 of 1 per cent. for all incomes beyond $20,000,000.

I claim, therefore, without fear of contradiction, that this formula really represents the true intent and efforts of the framers of the present law, who, not being mathematicians, have certainly done an admirable piece of near mathematical work, when this lends itself so well to an approximation by a mathematical formula; and who, accordingly, cannot very well be blamed for the not inconsiderable relative injustices the present law imposes on certain incomes. Such injustices, however, are incontestably revealed by a comparison of the law and the formula, and should be corrected.

This formula also brings out, as a fact, that the exemption of any income, no matter how small, is a mathematical absurdity, and thus points a way to its own modification, such that it will impose taxes so low on very small incomes, that these will be more nominal than actual, a matter that will be fully treated later on.

2. A scientific way of selecting ever-increasing incomes at which increased tax rates should be levied, together with corresponding tax rates, such that the resulting taxes will practically agree with the taxes called for by any formula, for all incomes thus selected; if, after all, taxing by a formula, no matter how simple, should be deemed inexpedient—a point no engineer, however, can concede for a moment.

3. A general formula that is believed to be eminently suitable for a graded tax, and which, with appropriately differentiated values of one of its constants, is equally applicable to single men and married men with or without children.

4. A formula that is the result of a combination of the final tax formula proposed, with Pareto's law of incomes, as it has been found also to apply to the United States by Prof. Erving Fisher, the well-known economist of Yale University, and at present president of the

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† Presented before the Philadelphia Section of the American Society of Mechanical Engineers, at the Engineers' Club, February 26, 1918.

* After my first efforts in this matter I was fortunate enough to be accorded an interview with Prof. T. S. Adams, the tax expert in the Treasury Department, who was at once ready to see the possibilities of my efforts, and to whose encouragement my subsequent work is largely due.

TABLE I

The Present Income Tax Law as it Applies to Married Men Whose Exemption is $2,000.00. By Incomes is Here Meant the "Net Taxable Incomes"

A	B	C	D	E	F
Incomes at which change of tax rate takes place, and tax rates	Difference between incomes listed in column A	Actual taxes for incomes listed in column A	Difference of figures in column B	Difference of tax rates in column A	Difference of figures in column E
0 0 per cent.	$2,000	0.00			
$2,000 2 per cent.	2,000	0.00 $40.00	0	2	0
4,000 4 per cent.	1,000	40.00 40.00	−1,000	2	−1
5,000 5 per cent.	2,500	80.00 125.00	1,500	1	0
7,500 6 per cent.	2,500	205.00 150.00	0	1	0
10,000 7 per cent.	2,500	355.00 175.00	0	1	0
12,500 8 per cent.	2,500	530.00 200.00	0	1	0
15,000 9 per cent.	5,000	730.00 450.00	2,500	1	2
20,000 12 per cent.	20,000	1,180.00 2,400.00	15,000	3	1
40,000 16 per cent.	20,000	3,580.00 3,200.00	0	4	1
60,000 21 per cent.	20,000	6,780.00 4,200.00	0	5	0
80,000 26 per cent.	20,000	10,980.00 5,200.00	0	5	0
100,000 31 per cent.	50,000	16,180.00 15,500.00	30,000	5	−1
150,000 35 per cent.	50,000	31,680.00 17,500.00	0	4	2
200,000 41 per cent.	50,000	49,180.00 20,500.00	0	6	−1
250,000 46 per cent.	50,000	69,680.00 23,000.00	0	5	−1
300,000 50 per cent.	200,000	92,680.00 100,000.00	150,000	4	0
500,000 54 per cent.	250,000	192,680.00 135,000.00	50,000	4	1
750,000 59 per cent.	250,000	327,680.00 147,500.00	0	5	1
1,000,000 65 per cent.	500,000	475,180.00 325,000.00	250,000	6	−5
1,500,000 66 per cent.	500,000	800,180.00 330,000.00	0	1	0
2,000,000 67 per cent.	3,000,000	1,130,180.00 2,010,000.00		1	−1
5,000,000 67 per cent.	5,000,000	3,140,180.00 3,350,000.00		0	
10,000,000 67 per cent.	10,000,000	6,490,180.00 6,700,000.00			
20,000,000		13,190,180.00			

American Economic Association, which will give the total tax of all taxpayers enjoying incomes between a maximum and minimum.

5. Finally, numerous tables and diagrams that simply and clearly set forth the arguments in the whole matter.

Let us now look at the law as it stands, and as it is represented in Table I, in which the rates of 1916 and 1917 are combined into a single rate and applied in a perfectly obvious manner to obtain the actual taxes for the "master" incomes of the law. Noting first the difference between the incomes listed in column A as listed in column B, and then the differences of these differences as listed in column D, we at once become cognizant of the arbitrary selection of the incomes listed in column A and their absolute lack of conformity to any mathematical regularity. To be sure, they reveal a great desire for even amounts, and within certain limits this is a laudable desire that should receive some consideration, tho surely only a secondary one in a matter of this kind.

In column E are also listed the differences between the tax rates listed in column A, and the differences of these differences are finally listed in column F. These reveal a similar lack of regularity, and help to condemn the whole arrangement of both the incomes and the rates listed by the present law.

Let it be said, however, that the lack of regularity in the tax rates to a remarkable extent offsets the lack of regularity in the incomes to which they apply, so that the final result is not nearly so bad as a superficial glance at the figures would indicate, and it is difficult to understand how such an unmathematical treatment of the whole matter has succeeded so well in establishing a graded tax that does not impose greater relative injustices than it actually does.

But now, for the exposure of the relative injustices as they incontrovertibly exist, which is made only in the spirit of constructive criticism, and with the understanding that I have no knowledge on which to base any criticism for or against the absolute justice of a graded income tax.

What is intended is to point out a systematic and scientific way of ironing out the kinks in the present law, which is also the intent of the amendment to the present law proposed some months ago by Senator Smoot, of the Senate Finance Committee, to which comparative reference will be made later.

In Table II are relisted the incomes and their corresponding tax amounts of the present law as they respectively appear in columns A and C of Table I, and also the corresponding tax amounts as figured by the formula already referred to as representing the law with a remarkable degree of approximation, and in addition hereto the particular incomes at which the law and the formula give identical tax amounts.

This comparison of the law with the formula is also shown graphically in diagrams No. 1 and No. 2, in which the full-line curve represents the formula and the dotted line the law. Diagram No. 1 is on a larger scale than

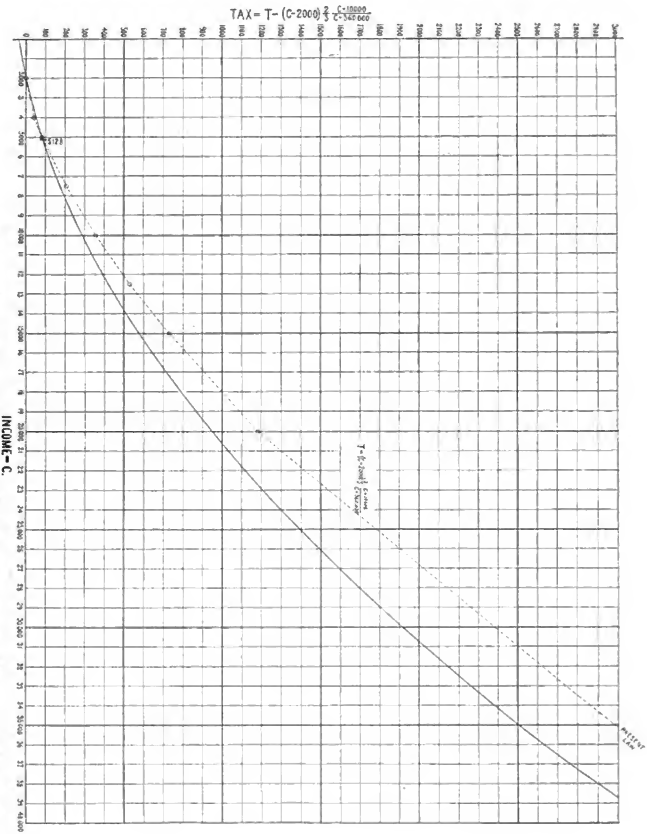

DIAGRAM I. COMPARISON OF THE LAW AS REPRESENTED BY THE DOTTED BROKEN LINE, WITH ITS APPROXIMATION FORMULA (I) AS REPRESENTED BY THE FULL-LINE CURVE. SEE TABLE II.

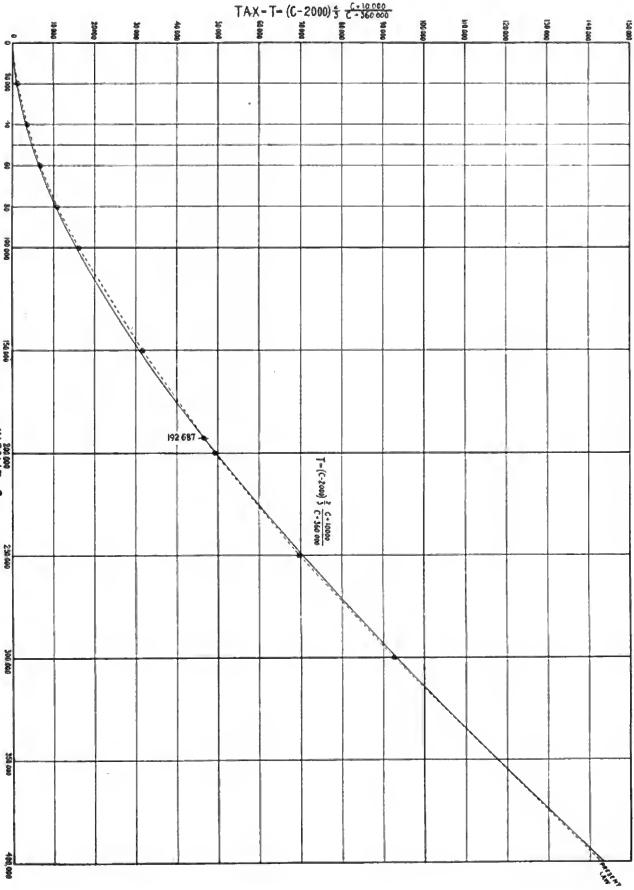

DIAGRAM II. COMPARISON OF THE LAW AS REPRESENTED BY THE DOTTED BROKEN LINE, WITH ITS APPROXIMATION FORMULA (I) AS REPRESENTED BY THE FULL-LINE CURVE. SEE TABLE II

TABLE II

Amount of Tax

Comparison of present law with the formula:

$$T=(C-2{,}000)\,\frac{2}{3}\,\frac{C+10{,}000}{C+360{,}000}$$

Note the exact agreement for the following incomes: 2,000—5,128—192,687—2,251,000, and also the exceedingly close agreement for 350,000.

The maximum overtaxation in dollars and cents occurs at about $33,000 and amounts to about $478.76, while the maximum in per cent. occurs at about $23,500 and amounts to nearly 28 per cent.

Incomes	Present law	By formula	
$2,000	0	0	
3,000	$20.00	$23.87	Undertaxation
4,000	40.00	51.28	
5,000	80.00	82.19	
5,128	86.40	86.40	
7,500	205.00	174.60	Overtaxation
10,000	335.00	288.29	
12,500	530.00	422.82	
15,000	730.00	577.77	
20,000	1,180.00	947.37	
23,500	1,600.00	1,252.71	
33,000	2,740.00	2,261.24	
40,000	3,580.00	3,166.47	
60,000	6,780.00	6,444.44	
80,000	10,980.00	10,636.36	
100,000	16,180.00	15,623.19	
150,000	31,680.00	30,954.25	
192,687	46,620.44	46,620.44	
200,000	49,180.00	49,500.00	Undertaxation
250,000	69,680.00	70,469.94	
300,000	92,680.00	93,313.13	
350,000	117,680.00	117,633.85	
500,000	192,680.00	196,883.72	
750,000	327,680.00	341,429.43	
1,000,000	475,180.00	494,107.84	
1,500,000	800,180.00	810,745.52	
2,000,000	1,130,180.00	1,134,457.62	
2,251,000	1,298,350.00	1,298,350.81	
5,000,000	3,140,180.00	3,114,425.37	Overtaxation
10,000,000	6,490,180.00	6,440,148.01	
20,000,000	13,190,180.00	13,102,815.32	

No. 2 and clearly shows how both lines start from an income of $2000 with no tax, how the dotted line falls slightly below the curve up to the income $5128, thus reflecting the field of undertaxation with which the law starts out as marked in Table II, and then quickly rises above the curve up to the income $33,000, after which it again approaches the curve to cross it a second time at the income $192,687, as shown on diagram No. 2. We thus also have followed the first field of overtaxation of the law, as marked in Table II between the incomes $5128 and $192,687. From the latter point on, the dotted line again falls below the curve as it enters the second field of undertaxation, as marked in Table II between the incomes $192,687 and $2,251,000, at which latter point it enters the second and final field of overtaxation. Unfortunately the diagram, not reading beyond the income $400,000, does not show this last point of coincidence between the dotted line and the curve, but, with an eye on the latter part of Table II, it is now readily pictured in the interested reader's mind.

The close approach of the tax by the law to that of the formula for the income $350,000 also shows very clearly in diagram No. 2, which also shows the wonderfully close average agreement between the law and the formula which I finally succeeded in constructing after trying out and discarding a great many of various forms. In fact, if in this formula the fraction ⅔ was written 0.67, and the constants 10,000 and 360,000 were slightly modified, it could be made to agree even more closely for incomes beyond $2,500,000 or so; but I have thought justified in reading into the 67 per cent. rate of the law on all incomes in excess of $2,000,000 a rounding up of the decimal equivalent 0.66666—of the fraction ⅔, which I have imagined the framers of the law really had in mind as the ultimate limit of their graded taxation scheme. But diagram No. 1 shows us more; namely, that the formula logically implies that a negative tax be levied on incomes below the exemption of $2000, as the full curve representing the formula falls below the base line for incomes between 0 and $2000. In other words, if it be granted, as I feel it must be, that the formula does in the main represent the *true intent and efforts* of the framers of the present law, it follows that these, in their unmathematical attempt at solving a mathematical problem, have unintentionally, but nevertheless absolutely, committed themselves to pay a subsidy to married men whose incomes are less than $2000 per year, to the extent shown in Table No. III, which has been figured by the formula.

TABLE III

Incomes	Negative tax or subsidy
0	37.02
100	35.53
500	29.13
1000	20.31
1500	10.60
2000	0

And, as it is impossible to construct a graded tax formula of any kind based on an exemption, that would not lead to a similar or an even worse absurdity,* we see that no exemption can logically be allowed either single or married men; and that it thus becomes logically necessary so to arrange a graded tax that all incomes, however small, are at least nominally subject to a tax. But before proceeding with the presentation, discussion, and recommendation of a tax formula of this kind, let us have another look at the defects of the present law, as they will now be further pointed out in connection with diagram No. 3. In this diagram the scheme of taxation of the present law is presented in the most conspicuous and convincing manner.

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* By absurdity I have reference only to the absence of any intention to pay a subsidy to citizens whose incomes fall below an amount at which a tax levy ceases. Who can tell what the future has in store? And considered by itself, perhaps it would not be at all absurd to pay a subsidy to a poorly paid bread winner of a large family.

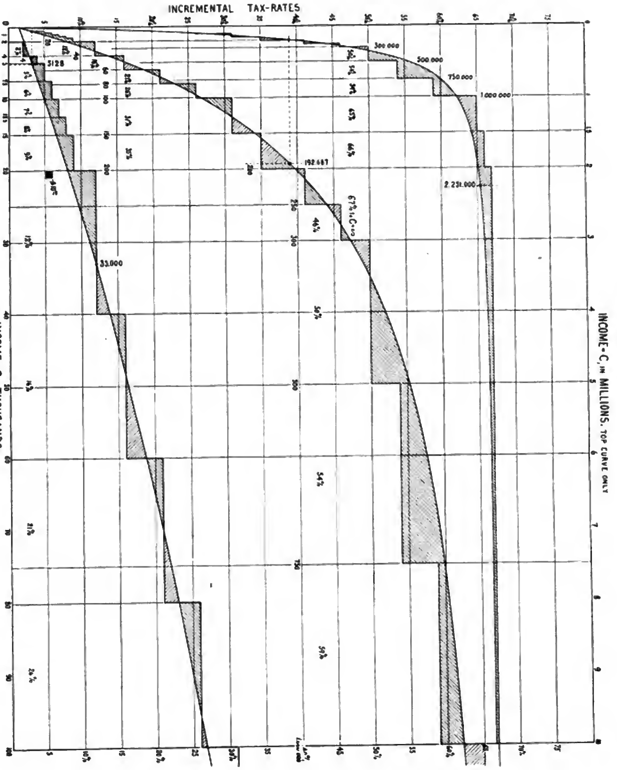


DIAGRAM III. GRAPHICAL REPRESENTATION OF TABLES I AND II, SHOWING THE DISCREPANCIES BETWEEN THE LAW AND FORMULA (I). THE SHADED AREAS ABOVE THE SMOOTH CURVE INDICATE FIELDS OF OVERTAXATION; THOSE BELOW THIS CURVE, FIELDS OF UNDERTAXATION.

The three main fields of the diagram cover respectively: the bottom field, incomes up to $100,000, on a comparatively large scale; the middle field, incomes up to $1,000,000, on a scale equal to 1/10 of the former; and, finally, the top field, incomes up to $10,000,000, on a scale equal to 1/100 of that of the bottom field; while in all three fields the scale is the same for the percentage of tax levied in the various fields of incomes.

Turning our attention first to the main bottom field of the diagram and the income $2000 at which taxation begins at two per cent., we have here the forty dollars of tax between 0 and $4000, represented by the little rectangle in which two per cent. is written, such that half of this rectangle similarly represents the tax up to $3000. Similarly, the rectangle between the incomes $4000 and $5000, the upper part of which is shaded and in which four is written, represents the additional tax on $1000 at four per cent., or an additional forty dollars. Again, the rectangle between the incomes $5000 and $7500, the upper part of which is also shaded and in which five is written, represents a further additional tax on $2500 at five per cent., or $125, and so on thru the whole diagram, such that the total area covered by all the rectangles from the income $2000 up to any other income, represents the total tax on such latter income. The curve, the area between which and the upper limit of each rectangle is shaded, represents the gradually increasing tax-rate that corresponds to the formula

$$T = (C - 2000)\,\tfrac{2}{3}\cdot\frac{C+10,000}{C+360,000}\ \text{(I)},$$

and as such is the graphical representation of the first derived function of this formula; namely,

$$\frac{d\,T}{d\,C} = \tfrac{2}{3}\cdot\frac{C(C+720,000)+2,900,000}{(C+360,000)^2}\ \text{(II)}.$$

That area between the base line of the diagram and this curve which lies between any two incomes, accordingly represents that tax between these incomes which is called for by formula (I). The shaded areas that lie above the curve in the diagram represent the overtaxation of the law in the various fields, while the shaded areas that lie below the curve similarly represent the undertaxation of the law, such that, when once understood, the diagram most clearly and conclusively demonstrates not only the lack of continuity, but also the lack of regularity in the attempted compromises in the present law. For the third time, the diagram also most clearly shows that there is a relative undertaxation from $2000 up to $4000, and relative overtaxation all the way from $4000 to $33,000, such that the undertaxation below $4000 is exactly balanced by the overtaxation between $4000 and $5128. Between $33,000 and $192,687 over- and undertaxation so alternate, with the excess undertaxation so great between $150,000 and $192,687 that at this latter income the net result is again a coincidence with the formula. Between $192,687 and $350,000 the alternating undertaxation and overtaxation will be seen to balance each other pretty well, as previously shown in Table II; but from $350,000 up to $1,000,000 the whole field will be seen to be undertaxed to an extent that amounts to a veritable discrimination in favor of all incomes between these limits. Then turning to Table II, we see that the tax for $1,000,000 is only $475,180, while the formula calls for $494,107.84, or a difference of $18,927.84, an amount which it will take the overtaxation on a large number of small incomes to cover, even if it in itself amounts to less than four per cent. By the sudden jump of the tax rate from 59 per cent. to 65 per cent. at $1,000,000, this undertaxation is again balanced by a portion of the final field of overtaxation, at about $2,251,000.

Not only does this diagram bring out the grosser mistakes of the law, but it also shows up in the clearest possible way the unavoidable minor injustices of any scheme of graded taxation with definite steps of percentages, and makes it perfectly plain that full relative justice can be meted out only by taxing according to a continuous formula. However, before we proceed to the consideration of the form of formula that will eventually be recommended in this paper, we will first see how we, with formula (I) as a basis, may arrange a scheme of graded taxation by steps that at least will be a great improvement over the present law, and reduce the relative injustices to a minimum. For this purpose I first reason that the gradually increasing distances between the incomes to be selected, at which higher rates are to be applied, must themselves follow some simple mathematical law, at least approximately; and arranging them in a geometrical progression naturally suggests itself. After giving this a little study I have selected the following incomes as a basis:

10,000—15,000—22,500—33,500—50,000—70,000—100,000

These are fairly even figures and at the same time form approximately a geometrical progression, the average ratio between them being $\sqrt[6]{\frac{100,000}{10,000}} = \sqrt[6]{10} = 1.467$ with a maximum of $\frac{15,000}{10,000} = \frac{22,500}{15,000} = 1.5$, and a minimum of $\frac{70,000}{50,000} = 1.4$.

With these figures as a basis, I build up indefinitely by multiplying them by 10 as often as required to cover the greatest income, and divide by 10 to get down to just below the exemption figure 2000, thus:

1500—2250—3350—5000—7000—10,000,

which figures I then modify to

2000—3000—4500—6700—10,000,

in order to get a start at 2000. The whole series of incomes arranged according to this scheme are listed in column A of Table IV, together with such tax rates (to the nearest 0.1 or 0.01) applied to the differences of these incomes as listed in column B, which will bring the resultant total tax for any income listed, to perfect agreement with the tax as calculated by formula (I) and listed in

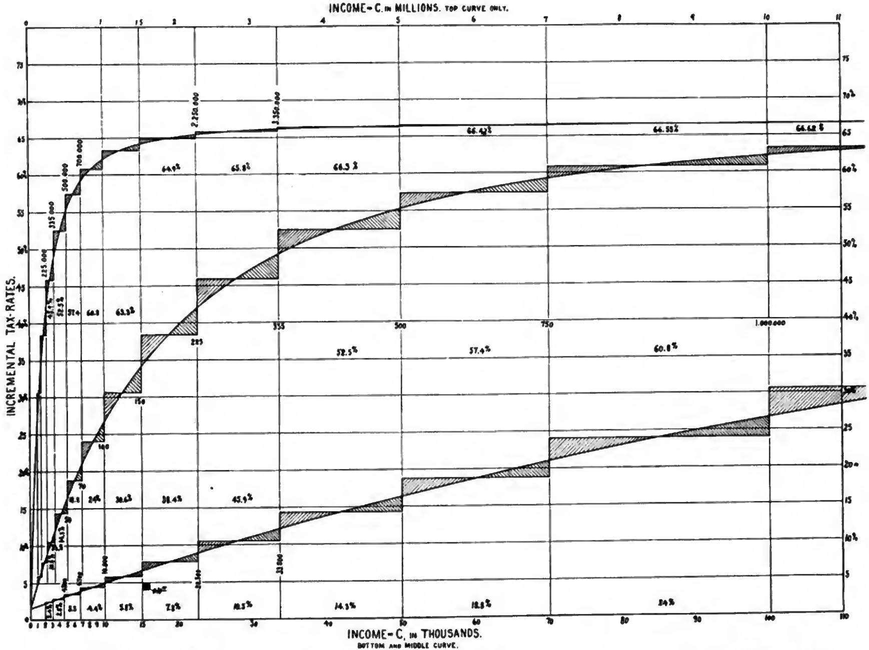


DIAGRAM IV. GRAPHICAL REPRESENTATION OF TABLE IV, SHOWING IMPROVED SCHEME OF STEP-TAXATION WITH FORMULA (I) AS A BASIS. NOTE HOW OVERTAXATION AND UNDERTAXATION NEUTRALIZE EACH OTHER IN EACH AND EVERY FIELD.

TABLE IV

Improved Step Taxation Illustrated in Connection with Formula (I).

A	B	C	D
Incomes at which change of tax rate takes place, and tax rate	Difference between incomes listed in column A	Taxes as figured by rates listed in column A	Taxes as figured by formula I
$2,000 2.4	$1,000	0.00 $24.00	0.00
3,000 2.8	1,500	24.00 42.00	$23.88
4,500 3.5	2,200	66.00 77.00	66.30
6,700 4.4	3,300	143.00 145.20	142.70
10,000 5.8	5,000	288.20 290.00	288.29
15,000 7.8	7,500	578.20 585.00	577.78
22,500 10.5	11,000	1,163.20 1,155.00	1,161.22
33,500 14.3	16,500	2,318.20 2,359.50	2,321.47
50,000 18.8	20,000	4,677.70 3,760.00	4,682.92
70,000 24.0	30,000	8,437.70 7,200.00	8,434.10
100,000 30.6	50,000	15,637.70 15,300.00	15,623.19
150,000 38.4	75,000	30,937.70 28.800.00	30,954.25
225.000 45.9	110,000	59,737.70 50,490.00	59,720.80
335,000 52.5	165,000	110,227.70 86,625.00	110,201.43
500.000 57.4	200,000	196,852.70 114,800.00	196,883.72
700,000 60.8	300,000	311,652.70 182,400.00	311,685.53
1,000,000 63.3	500.000	494,052.70 316,500.00	494,107.84
1,500,000 64.9	750,000	810,552.70 486,750.00	810,745.54
2,250.000 65.8	1,100,000	1,297,302.70 723,800.00	1,297,696.04
3,350,000 66.3	1,650,000	2,021.102.70 1,093,950.00	2,021,433.96
5,000,000 66.42	2,000,000	3,115,052.70 1,328,400.00	3,114,425.37
7,000,000 66.55	3,000,000	4,443,452.70 1,996,500.00	4,443,476.45
10,000,000 66.62	5,000,000	6,439,952.70 3,331,000.00	6,440,148.01
15,000,000 66.64	7,500,000	9,770,952.70 4,998,000.00	9,770,832.47
22,500,000 66.66	∞	14,768,952.70	14,769,025.95

column D—the actual taxes as obtained by the thus slightly erroneous tax rates being listed in column C.

It will be seen that the differences between the figures in columns C and D are everywhere so small that, compared with the discrepancies between the law and the formula as so fully pointed out above, they may be overlooked.

Graphically this comparison is represented in diagram No. 4, which in principle is the same as diagram No. 3. The shaded areas above the curve in all three major fields of the diagram also here represent the overtaxations by this latter mode of "step taxation" as compared with formula (I), and the shaded areas below the curve the undertaxations. It will be seen at once how practically exactly these neutralize each other in each and every field of this scheme of step, field, or block taxation, whichever term is the most appropriate; while it will also be realized that every income that falls within the lower half limit of any of these fields of a uniform tax rate, is saddled with an overtaxation which, at its maximum near the middle of each field, amounts to a relative injustice that is by no means negligible, even in this greatly improved scheme of step taxation based on a mathematical formula as a substitute for the guesswork done by the framers of the present law. This guesswork, however, as has already been admitted and pointed out, is a wonder of its kind.

If a diagram, similar to Nos. 1 and 2, were made to represent the scheme of step taxation represented in diagram No. 4 and Table IV, the same would appear as a broken dotted line whose corners would fall practically exactly on the curve that represents formula (I), and which then would not deviate greatly from the curve at any point. Diagram No. 5 illustrates the same scheme of step taxation, but with a different formula represented by the curve, which formula will now be presented and discussed as of a more rational and simple form than formula (I). In fact, it is so simple that there should be no real difficulty in adopting it directly in taxation, to avoid the relative injustices that are inherent in any scheme of step taxation, as so fully pointed out in the foregoing.

Reference has already been made to the amendment to the present law proposed by Senator Smoot, and if my understanding of it is correct, the same consists in merely dropping the two per cent. normal tax of 1916 from the present law, and thus retain only the two per cent. normal tax of 1917, together with the combined sur-taxes of 1916 and 1917. As it is the sudden addition of the two per cent. normal tax of 1916, beginning with an income of $4000, to the two per cent. normal tax of 1917 that begins at $2000 which is the cause of the first and relatively greatest field of overtaxation in the present law, the Smoot amendment would do much greater relative justice in this field of incomes, while it would not materially affect the field of greatest undertaxation, as this is due to discrepancies in the sur-taxes imposed in this field.

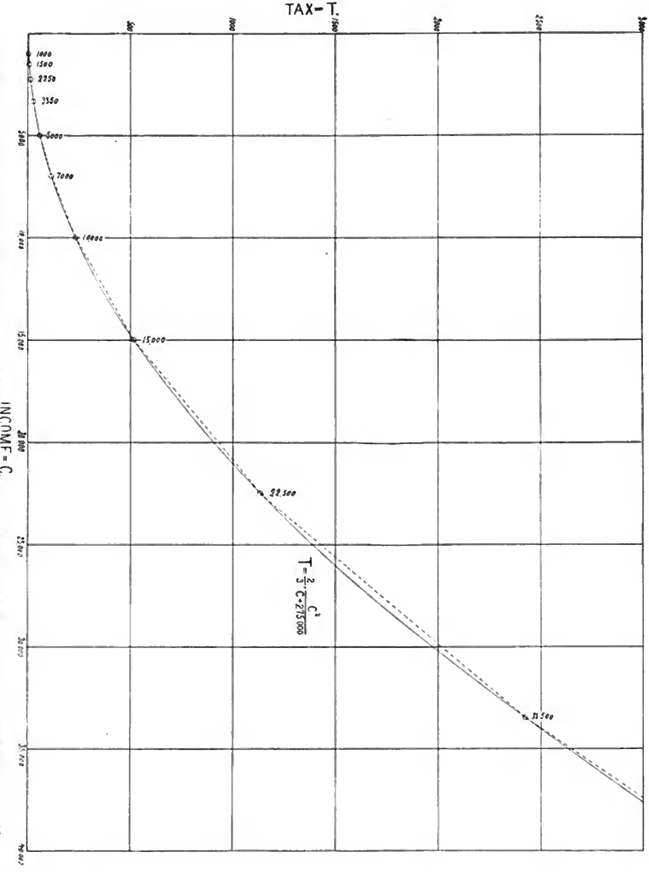


DIAGRAM V. COMPARISON OF IMPROVED STEP TAXATION AS REPRESENTED BY THE DOTTED BROKEN LINE, WITH THE CONTINUOUS FORMULA (III) AS REPRESENTED BY THE FULL-LINE CURVE.

A comparison of the present law, the Smoot amendment, and the formula just referred to above, which is

$$T=\tfrac{2}{3}\cdot\frac{C^2}{C+275{,}000,}\quad\text{(III)}$$

is made in Table V, and again in diagrams Nos. 6 and 7. While the formula, nominally at least, allows no exemption, but levies taxes on incomes down to zero, it will be seen that the tax for any income below the married man's exemption of $2000 under both the present law and the Smoot amendment, is very small indeed, and even at $2000 amounts to only $9.63, or less than one-half of one per cent.

TABLE V

Incomes	Taxes of present law	by formula $T=\frac{2}{3}\frac{C^2}{C+275{,}000}$	by the Smoot amendment	
$500		$0.60		Tax by the formula is greater than by both the law and by the amendment.
700		1.18		
1,000		2.42		
1,500		5.42		
2,000	0	9.63	0	
3,000	20	21.58	20	
3,320	26.40	26.40	26.40	
4,000	40	38.23	40.00	Tax by the formula is less than by both the law and the amendment.
5,000	80.00	59.52	60.00	
7,500	205.00	132.74	135.00	
10,000	355.00	233.92	235.00	
12,100	502.00	340.00	340.00	
12,500	530.00	362.32	360.00	Tax by formula is less than by the law, but greater than by the amendment.
15,000	730.00	517.24	510.00	
20,000	1,180.00	903.96	860.00	
40,000	3,580.00	3,386.25	2,860.00	
51,632	5,441.12	5,441.12	4,488.48	
60,000	6,780.00	7,164.18	5,660.00	Tax by the formula is greater than both by the law and by the amendment.
80,000	10,980.00	12,018.78	9,460.00	
100,000	16,180.00	17,777.78	14,260.00	
150,000	31,680.00	35,294.12	28,760.00	
200,000	49,180.00	56,140.35	45,260.00	
250,000	69,680.00	79,365.08	64,760.00	
300,000	92,680.00	104,347.82	68,760.00	
500,000	192,680.00	215,053.76	182,760.00	
750,000	327,680.00	365,853.66	312,760.00	
1,000,000	475,180.00	522,875.82	455,260.00	
1,500,000	800,180.00	845,070.42	770,260.00	
2,000,000	1,130,180.00	1,172,161.17	1,090,260.00	
5,000,000	3,140,180.00	3,159,557.66	3,040,260.00	
9,494,217	6,151,305.39	6,151,305.39	5,197,484.16	
10,000,000	6,490,180.00	6,488,240.07	6,290,260.00	Tax by formula is less than by the law, but greater than by the amendment.
20,000,000	13,190,180.00	13,152,486.66	12,790,260.00	

At $3320 the tax by the formula drops to perfect coincidence with both the law and the amendment, after which it runs slightly below the amendment and rapidly more and more below the law, until at the income $12,100 it again coincides with the amendment. From here on it begins to exceed the amendment more and more and to approach the law, which it finally overtakes at the income $51,632. From this point it even exceeds the law up to the income $9,494,217, at which it once more drops below the law, to continue below it indefinitely but not materially, without, however, ever getting as low as the amendment.

We thus see that this new formula is a remarkable compromise between the present law and the Smoot amendment, and as such it is recommended for most careful consideration.

A very natural objection to it is that it provides no exemption; but it has previously been pointed out that any exemption whatever is a mathematical absurdity, and hence cannot logically be provided for in a mathematical formula for taxing purposes. However, for incomes for which the formula would levy taxes so low that it would not pay to collect them, there would be a sort of automatic exemption, tho even these small taxes might be collected in part by the issue of some kind of "income tax stamps," which conscientious and patriotic citizens of very small incomes would be glad to buy, and by so doing would be able to enjoy as full a pride in their citizenship as the multimillionaire who is forced to give up the greater portion of his income, whether he likes to or not, or whether or not there is any other justification for the enormously high rates imposed upon him than the temporary one that the money must be raised, and that, hence it must be taken from those who have it.

The general form of formula (III) is

$$T=\alpha\,\frac{C^2}{C+a}\quad\text{(IV)}$$

and it is not necessarily my idea that α should have the value ⅔, and *a* the value 275,000. These values have been assigned in formula (III) only to make it a compromise between the Smoot amendment and the present law, in the manner discussed above.

In diagram No. 5 this formula is again represented—namely, by the full-line curve—while the dotted broken line represents the same form of step taxation as represented in diagram No. 4, in connection with formula (I).

However, before proceeding with a further consideration and discussion of formula (IV), a still more rational method of selecting the incomes in a step-taxation scheme will be considered; for, turning again to diagram No. 4, it will be realized, if indeed the reader has not already discovered it for himself, that the geometrical progression method gives incomes unnecessarily close together beyond $2,000,000 or so. In this respect the framers of the present law have again been on the right track in applying an ultimate tax rate for all incomes beyond $2,000,000. In other words, tho, in the light of my labors, any scheme of step taxation must be emphatically condemned, I have resolved not to leave a stone unturned to devise one that will be beyond criticism. My labors to this end have been greater by far than all the rest, and have involved so much mathematical work that I shall refrain from doing more than present the results.

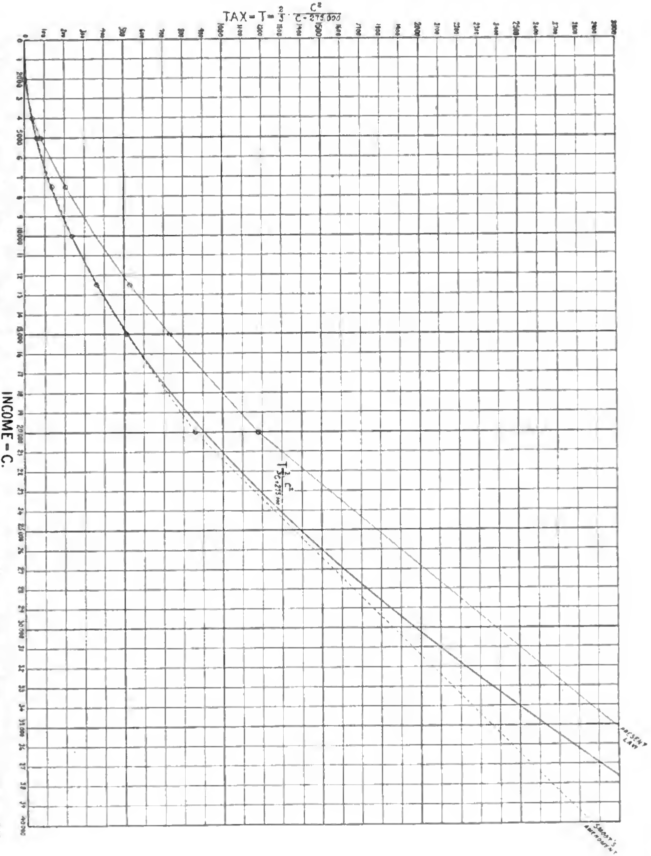


DIAGRAM VI. COMPARISON OF THE LAW AS REPRESENTED BY THE FULL-BROKEN LINE WITH THE SMOOT AMENDMENT AS REPRESENTED BY THE DOTTED BROKEN LINE, AND WITH FORMULA (III) AS REPRESENTED BY THE FULL-LINE CURVE

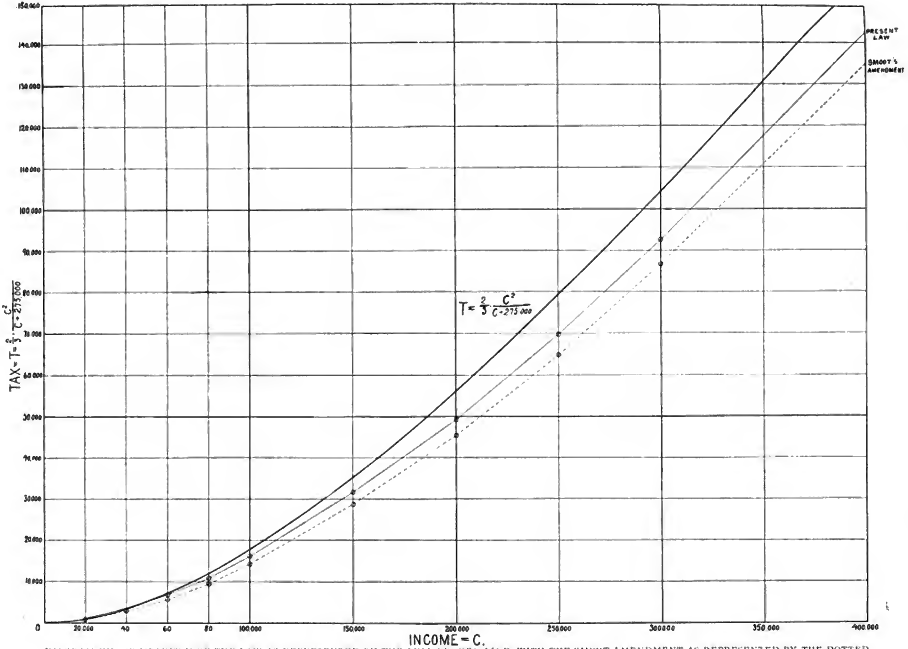


DIAGRAM VII. COMPARISON OF THE LAW AS REPRESENTED BY THE FULL-BROKEN LINE, WITH THE SMOOT AMENDMENT AS REPRESENTED BY THE DOTTED BROKEN LINE, AND WITH FORMULA (III) AS REPRESENTED BY THE FULL-LINE CURVE.

In this last scheme of step taxation the incomes (are arranged) at which a change of tax rate is to take place by the following formula:

$$C_x = C\frac{a\,n}{a\,(n-1)-C} \quad \text{(V)}.$$

in which C is the lower of two adjacent incomes; C_x the higher; a is the same constant as in formula (IV), and n is a number whose selection depends on the maximum proportional overtaxation we wish to limit ourselves to in our step taxation. Writing this formula:

$$\frac{C_x}{C} = \frac{a\,n}{a\,(n-1)-C}$$

we see that the ratio $\frac{C_x}{C}$ approaches the value $\frac{n}{n-1}$ as C approaches 0; while as the successive incomes increase, this ratio also increases, until, for the income $C = a(n-1)$, it becomes ∞. In other words, the formula expresses a law of formation of the incomes in this scheme of step taxation, which begins as a geometrical progression, and may be considered as a geometrical progression with a constantly increasing ratio which ultimately and rather suddenly becomes infinitely great, and thus puts an automatic limit on the number of incomes in the series.

With the values a equal 275,000 and n equal 5 introduced in formula (V), or

$$C_x = C\frac{1{,}375{,}000}{1{,}100{,}000-C}$$

this has been applied in the plan of step taxation illustrated in diagram No. 8, with formula (III), or

$$T = \tfrac{2}{3}\cdot\frac{C^2}{C+275{,}000}$$

as a basis. Table VI shows how this has been done, and also how the uneven income figures that the formula gives have been rounded up with a view to even figures, as entitled to some consideration.

It can be shown that, in spite of the ever-increasing ratio between two successive incomes adopted, the relative injustice in overtaxation for any income between these becomes less and less when measured in per cent., while in absolute dollars and cents it becomes greater and greater. This is inherent in formula (V), and was the object of its discovery.

Reverting now to a further consideration of the general formula (IV), or

$$T = a\frac{C^2}{C+a} \quad \text{(IV)}$$

in the first place, for the purpose of making a difference between single and married men, different values must be assigned to a. However, a certain value of a for single men might be adopted to serve for long periods at a time, together with a rule for its modification to apply to a married man or other head of a family, according to the size of his family; so that legislation of the value of a alone would have to be resorted to whenever a variation in the country's economic condition would necessitate a change.

TABLE VI

Second Improved Step Taxation as Illustrated in Connection with Formula (III)

Incomes and step tax rates by the formula $C_x = C\frac{1{,}375{,}000}{1{,}100{,}000-C}$		Taxes by this scheme of step taxation	Taxes by the formula $T=\frac{2}{3}\frac{C^2}{C+275{,}000}$
$500		$0.60	$0.60
0.27	125	0.34	
625		0.94	0.94
0.35	175	0.61	
800		1.55	1.55
0.44	200	.88	
1,000		2.43	2.42
0.54	250	1.35	
1,250		3.78	3.77
0.68	350	2.38	
1,600		6.16	6.17
0.86	400	3.44	
2,000		9.60	9.63
1.1	500	5.50	
2,500		15.10	15.20
1.3	700	9.10	
3,200		24.20	24.54
1.7	800	13.60	
4,000		37.80	38.23
2.1	1,000	21.00	
5,000		58.80	59.52
2.7	1,400	37.80	
6,400		96.60	97.04
3.4	1,600	54.40	
8,000		151.00	150.76
4.1	2,000	82.00	
10,000		233.00	233.92
5.1	2,500	127.00	
12,500		360.00	362.32
6.5	3,500	227.50	
16,000		587.50	586.49
7.9	4,000	316.00	
20,000		903.50	903.96
9.8	5,500	539.00	
25,500		1,442.50	1,442.60
12.1	7,000	847.00	
32,500		2,289.50	2,290.00
14.9	9,000	1,341.00	
41,500		3,630.50	3,627.70
18.0	11,000	1,980.00	
52,500		5,610.50	5,610.69
21.7	14,500	3,146.50	
67,000		8,757.00	8,750.49
25.8	19,000	4,902.00	
86,000		13,659.00	13,658.36
30.6	26,000	7,956.00	
112,000		21,615.00	21,608.97
36.0	38,000	13,680.00	
150,000		35,295.00	35,294.12
41.7	50,000	20,850.00	
200,000		56,145.00	56,140.35
47.4	75,000	35,555.00	
275,000		91,700.00	91,666.67
52.9	115,000	60,835.00	
390,000		152,535.00	152,481.20
58.0	210,000	121,800.00	
600,000		274,335.00	274,285.71
62.1	400,000	248,400.00	
1,000,000		522,735.00	522,875.82
64.9	1,000,000	649,000.00	
2,000,000		1,171,735.00	1,172,161.17
66.6	18,000,000	11,988,000.00	
20,000,000		13,159,735.00	13,152,486.66

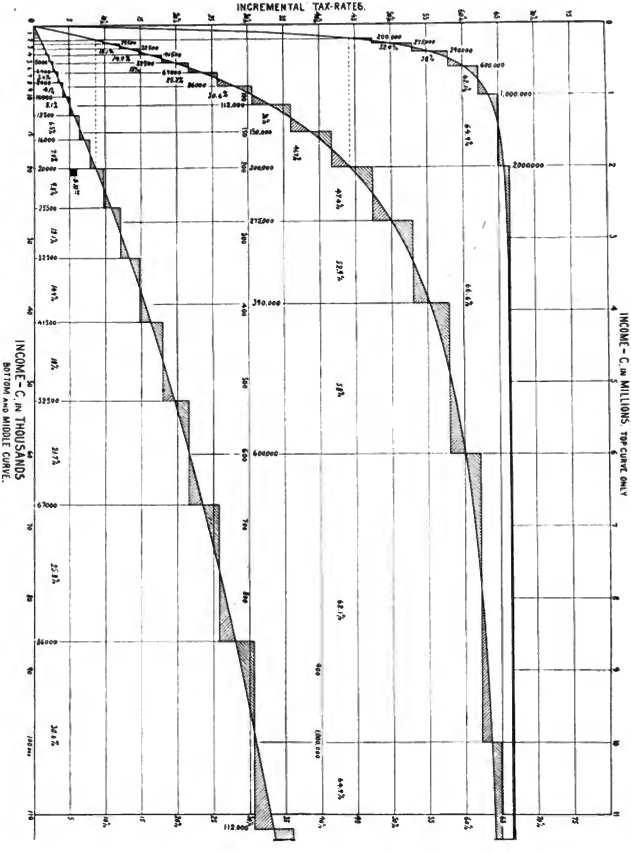


DIAGRAM VIII. GRAPHICAL REPRESENTATION OF TABLE VI, SHOWING SECOND IMPROVED SCHEME OF STEP TAXATION WITH FORMULA (III) AS BASIS.

As an illustration, the formula for single men might be written:

$$T_s = \tfrac{2}{3} \cdot \frac{C^2}{C + 200{,}000} \quad \text{(VI)}$$

and for married men with N children:

$$T_m = \tfrac{2}{3} \cdot \frac{C^2}{C + 200{,}000 + 75{,}000 \left[1 + \frac{N}{5}\right]} \quad \text{(VII)}$$

For a married man without children formula (VII) would then revert to formula (III), or

$$T = \tfrac{2}{3} \frac{C^2}{C + 275{,}000.}$$

In Table VII are listed a few representative incomes between 0 and $10,000,000, with the corresponding taxes as figured for single men by formula (VI) and married men by formula (III), together with their differences and ratios; and it will be noted how the differences increase, with the incomes, from 0 up to $50,000 as a final limit: while the ratios decrease with the incomes, from 1.375 as a limit for the smallest incomes, to *1* for the largest. In other words, as his income increases, a single man's tax diminishes from a maximum possible of 37.5 per cent. in excess of a married man's tax to about 0.7 of one per cent. at an income of $10,000,000, the absolute excess of this tax being $47,707.64. This certainly appeals to me as a more equitable relation than the relation existing under the present law, which levies an excess tax on a single man as compared with a married man, which is based only on a $1000 difference in exemption, and which amounts to only $40 for all incomes exceeding $5000.

TABLE VII

Incomes	Tax on single men by formula $T = \frac{2}{3}\frac{C^2}{C+200{,}000}$	Tax on married men by formula $T = \frac{2}{3}\frac{C^2}{C+275{,}000}$	Difference = $\frac{2}{3}C^3 \frac{75{,}000}{(C+200{,}000)(C+275{,}000)}$	Ratio = $\frac{C+275{,}000}{C+200{,}000}$
0	0	0	0	$1.375*
$500	$0.83	$0.63	$0.23	1.374
1,000	3.31	2.42	0.89	1.373
2,000	13.20	9.63	3.57	1.371
4,000	52.28	38.23	14.05	1.368
10,000	317.46	233.92	83.56	1.357
40,000	4,444.44	3,386.25	1,058.19	1.313
100,000	22,222.22	17,777.78	4,444.44	1.250
500,000	238,095.24	215,053.76	23,041.48	1.107
1,000,000	555,555.55	522,875.82	32,679.73	1.063
5,000,000	3,205,128.21	3,159,557.66	45,570.55	1.015
10,000,000	6,535,947.71	6,488,240.07	47,707.64	1.007
∞	∞	∞	Limit = 50,000.00	Limit = 1

* Limit = 1.375.

We will now pass to a further discussing of the general formula (IV), or $T = \alpha \frac{C^2}{C+a}$

If in this α is made 1, and the same thus written

$$T = \frac{C^2}{C+a} \quad \text{(VIII)},$$

it will now be shown that the formula in this form may be considered as representing an ultimate limit in a graduated taxation scheme, and as such must be fully understood and consulted before a rational selection can be made of values for either α or a in formula (IV); for the value $\frac{2}{3}$ for α and the value 275,000 for a in formula (III) have found their way into this merely as a modification of the present law and the Smoot amendment, neither of which has any mathematically discoverable rational or scientific basis of any kind.

In diagram No. 9, formula (VIII) is represented by the upper curve against which any income and its corresponding tax are read in terms of a. The upper, full line, being at an angle of forty-five degrees, reads an income against the vertical scale as well as against the horizontal scale, so that the vertical distance between this line and the curve, represents the difference between an income and its tax, or what is left the taxpayer; and it will be seen how this amount more and more approaches the same value; namely, the value a, which is the constant vertical distance between the full forty-five degree line and the dotted forty-five degree line, which parallels it. Designating what is left the taxpayer, by L, this amount may be written

$$L = C - T = C - \frac{C^2}{C+a} = \frac{aC}{C+a} = a \frac{C}{C+a}$$

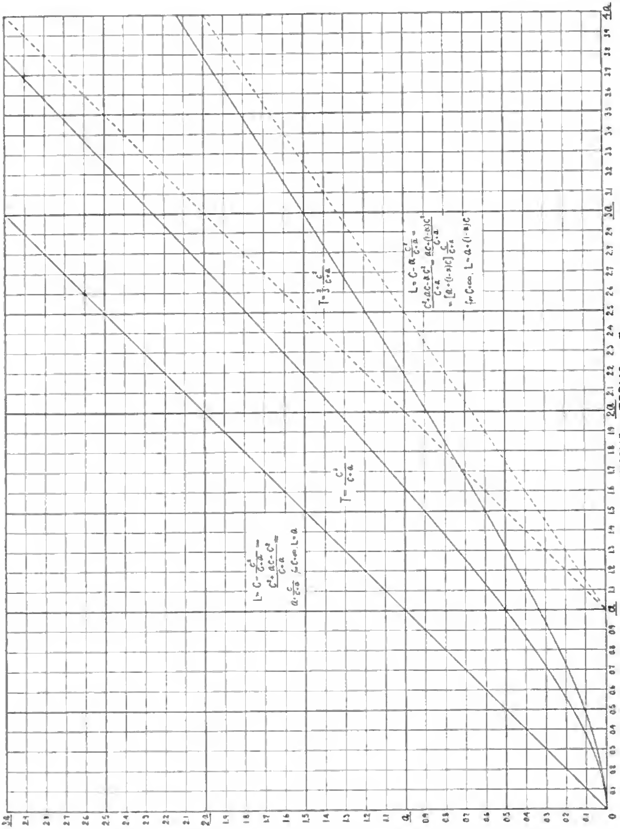
which, as C gradually becomes greater and greater, approaches the value a as a limit, as $\frac{C}{C+a}$ then approaches 1 as a limit; which is thus a proof of the statement just made above. It is because of this property of formula (VIII) that I have referred to it as expressing an ultimate limit in a graduated-tax scheme; for, actually applied in practice, it would mean the practical confiscation of all large incomes, except for an amount which can never reach the value a. For a practical taxation formula it is therefore necessary to assign a value to α in the general formula (IV) which is less than unity; and let us now see how much this general formula will leave the taxpayer. We have again:

$$L = C - T = C - \alpha \frac{C^2}{C+a} = \frac{C^2(1-\alpha) + aC}{C+a} =$$

$$[a + c\,(1-\alpha)] \;\frac{C}{C+a}$$

which, as C becomes greater and greater, approaches the value $L = a + C(1-\alpha)$ as a limit. That is to say, when α is assigned a value less than unity, a taxpayer of infinitely great income, and who as such would be left proportionally the smallest part of his income, would be left a certain definite fraction of his income in addition to the amount a. Thus, if tax is levied by formula (III), or $T = \frac{2}{3} \cdot \frac{C^2}{C + 275{,}000.}$ he would retain $275,000 plus $\frac{1}{3}$ of his income. It may now be realized that, while I have no intention that under any circumstances formula (VIII) should be used directly for tax purposes, it was with an eye on this formula that the suggestion was previously made for a more rational relation of a single man's tax to that of a married man.

Let me repeat that my recommendation is the adoption for a graded income, or other graded tax, of the general formula:



INCOME IN TERMS OF a.

DIAGRAM IX.
(For description, see page 295)

$$T = \alpha \frac{C^2}{C+a} \text{(IV)}$$

to be applied directly to single men, and modified to

$$T = \alpha \frac{C^2}{C+a+b\left(1+\frac{N}{m}\right)} \text{(IX)}$$

for married men, in which $N =$ number of children, and m a number which will depend on what consideration the number of children are deemed worthy of as compared with a wife. In the present law, which allows an exemption of $200 for each child, five children have the same consideration as their mother, and it was because of this that I wrote $m = 5$ in formula (VII). I also contend that values for a, b, and m might well be assigned to serve their purpose for any period, however long, during which the fundamental economic and social conditions of the country do not undergo any radical change, such that the value of α alone would be subject to change as often as the financial condition of the government might require more or less tax to be levied. However, in fixing a relatively permanent value for a, b, and m, their significance when α is made 1 should have the most careful consideration.

As a matter of purely theoretical interest, we may even write formula (IX) thus:

$$T = \alpha \frac{C^2}{C+a+b\left[n+\frac{N}{m}\right]} \text{(X)}$$

in which $n =$ number of wives, with only the two alternative possible values in Christian countries; namely, 0 for single men and 1 for married men. With $n = 0$, N must also be 0, in which case the formula reverts to formula (IV).

(End of Part I)

THE HEAVY OIL ENGINE

(Continued from Page 279)

either by its own crank or by rocker and links from other moving parts, then when the engine stops the water stops, and when the engine starts the water starts. That might seem to be a desirable thing at first glance. As a matter of fact, it is positively dangerous, and many cracked cylinders and piston heads can be traced to that cause alone; because, consider the interior of a cylinder when the engine is running at full power, and you will see that there are some hundred pounds of metal very hot—quite hot in proportion as it is thick. Now when that engine is shut down heat is there as insensible heat of the metal, and the jackets are full of water—X pounds of water and Y pounds of hot metal. If the weights and heats involved are figured out you will find in a big engine there is enough heat in the metal to evaporate all the water to steam and you would still have some left to conduct out to more distant parts, which should be cold—parts which are designed to be cold, but which, when hot, crack. Especially is that true when after such a shutdown and a general heating somebody starts the engine and shuts a lot of cold water up against the surface. That condition can be eliminated only by completely independent jacket water circulators separately driven by another engine, which permit the running of the water so long as water comes out from the discharge with any rise in temperature over the intake. In other words, the water should be continued thru such an engine until it ceases to become warm, and that may be from twenty minutes to half an hour after the shutdown, depending on the size and style of machine.

A similar discussion could be carried on about other auxiliaries. This question of auxiliary arrangement and starting by an auxiliary engine is just as important for study as the engine itself. There is just as much room for improvement as in the engine structure, as a structure, or the engine parts that are concerned with its functional operation.

Getting back now to the beginning, it must be admitted, and the more you study it the more willing you will be to admit it, that, while we have made very considerable progress with the heavy oil engine, that progress is by no means ended. In fact, we can go much further yet than we have already gone, and we can make the heavy oil engine meet conditions it has heretofore failed to meet.

ADDRESS*

By MAJOR J. A. VOGLESON, Retiring President

MAJOR J. A. VOGLESON, U. S. N. A.

It is a matter of regret to me that it is not practicable to be with you at the Annual Meeting and address you in performance of the duties of the position with which you have honored me during the past year.

Entering the military service of our country last January, and being far removed from the Club's activities, with duties in the field that call for close application, it has not been possible to enter into the work of the Club in the manner that a nearer approach would have permitted since that date. It is possible, however, to send you a word in greeting and to speak briefly of the work that has been done during the past year toward carrying forward development plans of the Club.

Our principal aim during the last two years has been based upon the idea of creating a center for Philadelphia and its immediate vicinity in which the various engineering activities of the section could find a means for expression on matters of professional interest, both technically and socially.

The year has been singularly marked by the successful efforts of the various committees who worked with unflagging interest to carry forward the Club's purpose and to fulfil the objects for which we are organized. Confronted as we have been by the conditions arising from a world-wide war, we still have made progress; and thru the work of those committees and the sustained interest of the membership-at-large, we have drawn nearer to the accomplishments desired. It had been my hope as your presiding officer that during the year all of the contemplated improvements could be carried into effect, and that the incoming officers could this year devote the time which is given to the affairs of the Club without the distraction of dealing with a building program. The times and conditions have not permitted the realization of that hope, but that our newly-elected officers will carry it much nearer to the desired goal, I have no doubt.

At the beginning of the fiscal year 1917–1918, the officers of the Club were confronted with the problem of how to carry on the work which the Club Development and Building Committees had accomplished up to that time. A state of war for our nation had been but recently declared. The demands for time and money were many and varied. As engineers, we would not retreat; nor did it seem fitting that trenches should be dug, but rather that we should go forward. The membership of the Club responded to the call with no little sacrifice, and has made possible the additions and improvements to our property which have been effected during the year.

The Annual Reports of the several committees have been presented to you, and in them you have doubtless found matters that are of much interest. To me they have been most encouraging for the future of our organization. Our membership thru the first year of warfare has been well sustained, and on March 31 was twenty-two hundred and twenty-four, or but one hundred and forty-one less than it was at the beginning of the fiscal year on April 1, 1917.

During the year, two additional local engineering societies have become affiliated with the Engineers' Club, and our total affiliated societies now number nine. The joint meetings made possible by affiliations enable our membership to hear papers of the highest order in all the various fields of engineering activities; and we believe that our affiliated societies also benefit by the closer association.

The Club Journal has been developed into a publication that has surpassed the imagination of its most sanguine supporters when the first departures were made by the editor of our former Bulletin, who had the vision to see that the former Proceedings could be developed, and had the courage to start and carry on.

All of our committees are important and vital to the welfare of the Club and have worked assiduously for its interests. The Committee on House and the Building Committee have worked most diligently for our creature comforts and added to them. To the Committee on Papers is due especial appreciation for the excellent series of papers which have been presented during the year. The Junior Section has become revitalized, and to this body of our membership the hand of good fellowship and encouragement should ever be extended.

The Club as a collective body has served the nation thru the work of its Committee on National Service. Two hundred and thirty-two, or one-tenth of our membership, are in the armed forces of the nation, and I believe there is none of our members who has not rallied to the service of our country in essential industrial work which must be performed to maintain our military, naval, and air forces.

There is that other function of waging war which is most vital to all arms of the service, and in this our Club must not be remiss. I refer to maintaining the national morale. Our country is at war. Let none of us forget that until this war has been successfully terminated. To win a war, as well as to successfully carry out a collective purpose, there must be such unanimity of action that the nation can act as one unit. We have come to the acid test of determining whether free people can rise to those degrees of organization which must be attained if our institutions shall survive the shocks that can be directed by governments whose fundamental tenets are that might is right and that a state has no moral obligations. That many millions of people are obsessed by such doctrine can not be denied; and that they have suffered and will suffer the hardships of untold privation and hunger and will die for their beliefs is written across the bleeding days of now almost four years of warfare. Opposing this doctrine have been sacrificial Belgium, heroic France, tenacious Britain and valiant Italy, fighting and bleeding for us thru the agonizing years of this war. Our country has spoken firmly, and we are rushing to the encounter, but let it be with humility that we pursue our task.

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* Presented at Thirty-ninth Annual Meeting, Engineers' Club, May 21, 1918.

There is no business so important, there is no need so great as our country's business and our country's need at this hour. We must realize this; we must act upon it to the fullest extent of our power in order to maintain those institutions for government which have been entrusted to us.

We cannot all go to the front; there is work to do in the field and mine and shop, and all the essential commercial mechanism must be kept in motion and must work efficiently. There must be the spirit of sacrifice and the will to endure. Let us think victory, talk victory, work for victory, humbly and prayerfully, never with boasting; not the victory of "might is right," but the victory that right makes the might, and build for the unanimity of action without which our sacrifice will be vain and our efforts futile.

There are duties for all in these hours of trial, but to engineers there have fallen very special duties and no small responsibility. Technical knowledge has made possible the scale of modern warfare. Thru the years of his patient labor the engineer has worked for the "comfort and convenience of man"; and to his skill is largely due many of the developments which make a world-wide war possible; and now, when we have come to a period in our history when our institutions will be tested to the utmost and where the paths of progress lead to construction thru destruction, I am sure that we, as engineers, shall not be found wanting either in the field or at home in applying our knowledge in the fullest measure for our country's service.

There is no glamour in a modern army cantonment, and for the grandeur of military trappings you will have to turn to the pages of your illustrated histories, and even they are, in part, figments of fancy, I fear, for war has always been grim business and is now even more grim, if degrees of comparison are possible. There is, however, in these camps a spirit and determination to see this grim task thru to a just peace. And there is at work a leaven of acquaintanceship which augurs well for our country's future.

With the soldier there will never be an East, West, North, or South, but one great nation. Both city and country-bred are vying in the spirit of service. The native-born is learning that in his fellow soldier of alien birth, brought to our shores by hope of freedom, can burn a devotion to duty equal to his own. Order and discipline are steadying forces, and when we return to our homes it will be with an awakened sense of responsibilities and duties which will make for better citizenship. One youth was heard to exclaim good-naturedly during his struggle at grubbing a stump from a company street: "Dad tried for twenty years to make me do something like this, but it took Uncle Sam to put it over." Just as that lad rose to the necessities of the occasion, so must we, as a nation, rise to our great task; for while war-making has not been our profession, war-ending is a holy purpose to which all our resources must be fully consecrated.

THE TROOPS OF THE AMERICAN EXPEDITIONARY FORCE WHICH MARCHED THRU LONDON WERE WATCHED BY KING GEORGE AND HIS MOTHER, QUEEN ALEXANDRA, WHO ARE SHOWN AT THE EXTREME RIGHT OF THIS PHOTOGRAPH

SAFETY FIRST FOR FOUNDRYMEN*

By ALEXANDER E. OUTERBRIDGE, Jr., Metallurgist

MORE than ten years ago, William Sellers & Company, Inc., manufacturers of machine tools, of Philadelphia, Pa., recognizing the growing need of a "Safety First" campaign, in their works, for the education of their employes, commenced to keep systematic records of all accidents occurring in all the departments. At the same time there was inaugurated a system, analogous to what is now known, in some large establishments, as a "Welfare Department," the main purpose of which was to give personal attention to men injured, to visit their homes and look to the welfare of their families while they themselves were incapacitated for labor.

Blank forms were prepared and all bosses were instructed to submit brief accounts of all accidents to the superintendent within twenty-four hours. An inspector immediately investigated such accidents and prompt measures were taken to preclude the possibility of repetition thereof.

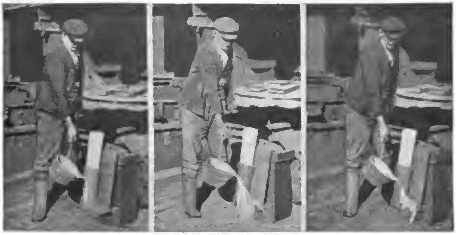

FIG. 1.—EXPERIMENTS CONDUCTED IN THE SELLERS FOUNDRY

A detailed summary was prepared each year, showing the number of accidents and, at the end of the first six years, an elaborate compilation was made giving the total number of accidents, classified under different headings, with percentages of same and showing the proportion, per hundred employes, of such accidents each year. The knowledge thus gained was both surprising and valuable. More than 50 per cent. of all the accidents were shown to have been clearly preventable by the exercise of ordinary care, and the largest single cause was due, not to operation of machinery at all, but was found under the head of "falling objects," being almost exactly 33 per cent. of the total number of accidents during the six-year period.

The immediate result of the information thus acquired was the preparation of a circular letter, issued to the foremen, giving instructions regarding their responsibilities, as well as those of their men, for the future prevention of such accidents, and later compilation of records show gratifying decrease in number of accidents from all causes, per hundred employes, since commencement of the records. This decrease is due partly to the result of the campaign of education which has been persistently carried out, causing a new spirit of caution to supplant the former one that prevailed to some extent of "taking chances," and partly to the complete methods adopted for preventing accidents by providing guards for gears and other moving parts of machinery.

The six-year compilation, already alluded to, showed that the largest cause of accidents in the foundry was due to "burns on legs and feet" from molten iron splashed from ladles or spurting from imperfectly closed molds. To cite a single case, a young married man who had worked three days only in this foundry spilled some molten iron over his shoes, which were old and cracked, causing painful burns on both feet. Notwithstanding prompt treatment at a hospital, blood poisoning set in and the man was incapacitated for many weeks.

Inquiries were immediately sent broadcast for any practicable protectors for preventing such accidents. When it was found that none was to be obtained, experiments were at once made by the metallurgist with asbestos cloth and other materials with some surprising results. Boards about one foot wide and two feet long were placed upright at an angle on the floor of the foundry and various fabrics tacked upon them. Molten iron was then dashed (not poured continuously) over these surfaces. It was soon found that closely woven smooth-faced fabrics (though combustible when exposed to a candle flame) shed molten iron like water from a duck's back. Even a sheet of paper was subjected to this "trial by fire" several times without flaming. It was at once

(*Continued on Page 312*)

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* *Pennsylvania Department of Labor and Industry Monthly Bulletin*, October 1916. Read before the Philadelphia Safety Council, at the Engineers' Club, March 25, 1918.

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Director-at-large

COMMITTEE ON PAPERS

LEWIS H. KENNEY, CHAIRMAN

The Meeting for June 18th, 1918, announced by the Committee in a previous issue of the Journal has been cancelled, with the approval of the Board of Directors.

REQUEST FOR SUGGESTIONS.

The Committee requests that the members of the Club and our Affiliated Societies volunteer suggestions as to subjects of papers and speakers, to assist the Committee in preparing a schedule of papers next year. Such information would greatly assist the incoming Committee in preparing its program in accordance with the desires of the membership.

Please address all communications to the Committee on Papers.

AN ACKNOWLEDGMENT

The present number of The Journal completes the year's issue under the direction of the retiring officers and committees and
The Publication Committee
desires in this place to express to the publishers
J. B. LIPPINCOTT COMPANY
and especially to
MISS RAE F. VICKERS, Committee Secretary
its hearty appreciation and recognition of their painstaking, efficient and generous efforts in aiding the Committee at all times in the performance of its work.

SECRETARY'S NOTICES

CANCELLATION OF MEETING

The Regular Meeting of the Club announced for June 18, 1918, has been cancelled, in accordance with the action of the Board of Directors taken at their meeting of May 14.

ABSTRACT OF MINUTES OF THE SPECIAL MEETING OF THE CLUB.

HELD MONDAY EVENING, APRIL 29, 1918, AT WITHERSPOON HALL

The meeting was called to order at 8:15 P.M. by Mr. J. F. Stevens. About 900 members and guests were present.

Dr. Frederic Poole delivered a lecture entitled "The Social, Political and Industrial Revolution of China," illustrated with colored slides and motion pictures.

A unanimous vote of thanks was extended to the speaker.

The meeting adjourned at 10:30 P.M.

ABSTRACT OF MINUTES OF THE THIRTY-NINTH ANNUAL MEETING

HELD TUESDAY EVENING, MAY 21, 1918, AT THE CLUB HOUSE

The meeting was called to order at 8.15 P.M., by Mr. John C. Trautwine, Jr. About 200 members and guests were present.

The minutes of the Joint Meeting of the Engineers' Club and the Philadelphia Section of the A. S. M. E. held March 27, and of the Business Meeting of the Club held April 16, as published in the JOURNAL, were approved.

Mr. J. Franklin Stevens announced that he had pledged the support of the Engineers' Club of Philadelphia to the local section of the National Fuel Committee on their request that our organization give them assistance in the technical examinations of the power plants of this district.

Announcement was made of the fact that the Annual Report of the Board of Directors had been published in the May JOURNAL of the Club.

The Annual Address by the retiring President, Major J. A. Vogleson, was read by Mr. Lewis H. Kenney, Chairman of the Committee on Papers.

Mr. John D. Gill (member) presented a paper, entitled "War Status of Gasoline and Fuel Oil," which was discussed by Messrs. Irish, Stevens, Trautwine, Jr., Hoopes, Gest and Hering.

Messrs. Alexander P. Gest and John J. Hoopes, members of the Club continuously since March 1, 1879, and October 16, 1880, respectively, were called upon to greet those present.

The Tellers presented the following report:

Mr. President and Members of
The Engineers' Club of Philadelphia.

GENTLEMEN:

Your Tellers have counted the votes cast for the election of officers, and declare that 248 legal ballots were cast, and the following officers elected:

OFFICERS

	Votes
For President (To serve until July 1, 1919)	
J. Franklin Stevens	246
For Vice-President (To serve until July 1, 1921)	
Joseph C. Wagner	247
For Treasurer (To serve until July 1, 1919)	
Lewis H. Kenney	246
For Directors-at-large (To serve until July 1, 1919)	
W. H. Connell	242
H. P. Gant	243
Walter E. Long	243
Paul Spencer	243
S. M. Swaab	245

Respectfully submitted,

Tellers GEO. E. CROFOOT,
JOHN P. MUDD,
CHAS. F. PUFF, JR.

The Chairman declared the nominees elected.

The meeting adjourned at 10.30 P.M.

ABSTRACT OF MINUTES OF THE REGULAR MEETING OF THE BOARD OF DIRECTORS

HELD MAY 14, 1918

The meeting was called to order at 7.30 P.M., with Vice-presidents Yarnall and Eglin, Directors Fernald, Henderson, Gant, J. C. Wagner, Kenney, S. T. Wagner, Forstall, Terrell, Douglas, Past Presidents Swaab, Ledoux and Carter, Treasurer Stevens, and Secretary Stockly in attendance. Mr. Dallett, Chairman of the Committee on Life Memberships, was also present, on request. President Vogleson, Vice-president Andrews, Directors Hayward, Moody, Ehle, G. W. Barr and R. M. Barr were excused.

The minutes of the Special Meeting of April 11, as issued to the members of the Board, were approved.

REPORT OF THE PRESIDENT

In accordance with authority granted at the April 11 meeting, Mr. H. E. Hilts has been appointed a delegate to represent the Club at the Annual Convention of the American Association of Engineers to be held in Chicago, May 14, 1918, and to submit a report of the Convention.

The following delegates were appointed to attend the convention of the League to Enforce Peace, held in Philadelphia, May 16 and 17:

J. W. Ledoux
W. P. Dallett
S. M. Swaab

REPORT OF THE SECRETARY

Announcement is made of the death, on March 19, 1918, of Mr. Fred L. Brown, Active Member.

The following representatives have been appointed by the Technology Club on our Board and Committees:

Board of Directors	Mr. Herbert A. Terrell
Meetings Committee	Mr. R. E. Page
Public Relations Committee	Mr. C. J. Walton

To date one hundred and eight members in the active service of the Government have applied for remission of their annual dues.

Resignations from the following members were presented and accepted as of April 1, 1918:

C. Edwin Bartlett
H. S. Battin
Harold S. Bell
Albert J. Blair
G. F. Blessing
Chester E. Boller
Ernest L. Bossinger
Robert M. Briner
James H. Browne
Joseph Cauffman
Louis J. Costa
James H. Costello
John S. Crandell
B. Currier
Albert W. Deininger
H. F. Deininger
William D. Eastwood
Wm. J. Finley
John P. Flood
William J. Gray
Justice Grugan
Douglas W. Haire
A. L. Hamma
Lewis H. Haupt
Robert D. Hawkins
G. Roscoe Heap
E. K. Heering
Abraham Henwood
Wm. F. Hudson
F. P. Jones, Jr.
Robert B. Krauss
Ralph J. Lawrence
Thomas P. McCutcheon, Jr.
J. F. McGarity, Jr.
A. C. Merrill
M. G. Moore
M. L. Mosher
Richard C. Newbold
B. A. Owen
Alfred G. Patton
T. B. Preston
Chas. A. Psilander
Unit Rasin
Arthur J. Rowland
Percy L. Reed
H. H. Roberts
M. H. Rodda
Elmer P. Rust
E. E. Sagendorph
Joseph B. Seaman
L. C. Schneider
Edw. A. Shallcross
George H. Stier
C. C. Tutwiler
Wm. Uzelmeier
Louis B. Walters
Henry R. Walton
Stafford R. Webb
Samuel T. Wilson

Thru an error which was ordered corrected, the name of Mr. George B. Taylor appeared with the list of resignations accepted at the April 11 Board meeting.

A letter has been received from the Secretary of the National Conference on City Planning, inviting the Club's representation at the National Conference to be held in St. Louis, Mo., May 27 to 29, 1918, and the President was authorized to appoint a delegate to attend the Conference.

REPORT OF THE TREASURER

The Treasurer presented a report which was accepted.

REPORT OF THE COMMITTEE ON MEMBERSHIP

The Committee presented a report, and the following were elected:

To *Active* Membership:

William D. Appleton
Frederick P. Bushnell
Charles E. Fisher
Thomas I. Goslin
Robert R. Elzey
Sedley H. Phinney
David E. Smiley
Horace Tomlinson
Edwin T. Wolf
Benjamin B. Wood

To *Junior* Membership:

Alfred K. Althouse
George K. Coleman
George A. Doyle
Frank W. Miller, Jr.

COMMITTEE ON CONSERVATION OF FUEL

The Committee reported that plans were in progress by the State Fuel Administration for a more rigid conservation of fuel during the coming winter, and that they would count on the coöperation of engineers in solving the problem.

The meeting adjourned at 8.55 P.M.

H. A. Stockly,
Secretary.

POSITIONS WANTED

Graduate mechanical engineer with 5½ years' experience as works engineer, and resident engineer on the manufacture of high explosives and acids. Apply Engineers' Club, No. 208.

Technical graduate in mechanical engineering, 12 years' experience in power plant and building construction and manufacture of metallic building equipment, desires to locate with manufacturer of engineering or building equipment specialities, preferable with sales department. Apply Engineers' Club, No. 210.

COMMITTEE ON MEMBERSHIP

D. ROBERT YARNALL, Chairman

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before June 10 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

JAMES G. CALEBAUGH

1503 Columbia Avenue, Philadelphia, Pa.

Manufacturing Carbon Products, Calebaugh Self-Lubricating Co., Inc.

Proposed by G. A. Pierce and George M. Spear.

GUY S. ELMORE

Swarthmore, Pa.

Engineer Coal and Ore Preparation, Manufacturer of Mining Machinery.

Proposed by H. M. Chance and T. M. Chance.

HARRY ARCHER HORNOR

Hamilton Court, Thirty-ninth and Chestnut Streets, Philadelphia, Pa.

Electrical Expert for Emergency Fleet, New York Shipbuilding Co.

Proposed by William F. James and H. Goodwin, Jr.

GILBERT C. LAMB

921 Witherspoon Building, Philadelphia, Pa.

Electrical Engineer, The American Railways Co.

Proposed by L. R. Lewis and H. P. Gant.

RICHARD V. MATTISON

Ambler, Pa.

Vice President and General Manager, Keasbey-Mattison Co.

Proposed by Charles E. Bonine and H. F. Sanville.

GEORGE H. MORGAN

15 W. Phil-Ellena Street, Germantown, Philadelphia, Pa.

Secretary, E. F. Houghton & Co.

Proposed by R. H. Horton and Lewis H. MacLaughlin.

WILLIAM WILCOX

1009 Commercial Trust Building, Philadelphia, Pa.

District Engineer, Whitlock Coil Pipe Co.

Proposed by Thornton Lewis and C. V. Haynes.

EDWARD WOODBURY

Central Y.M.C.A., Philadelphia, Pa.

Marine Electrical Engineer, American International Shipbuilding Corp., Camden, N. J.

Proposed by H. P. Liversidge and H. F. Sanville.

FOR ELECTION TO JUNIOR MEMBERSHIP

HOWARD FRANCIS COLLINS

1038 S. Fifty-fifth Street, Philadelphia, Pa.

Assistant Manager, Heating and Power Piping Dept., Globe Automatic Sprinkler Co.

Proposed by Harry W. Payne and George W. Baker.

KENNETH WARREN HEINRICH

5031 Chestnut Street, Philadelphia, Pa.

Steam Engineer Assistant, Philadelphia Navy Yard.

Proposed by H. T. McGaughan, J. L. Cozzens and L. H. Kenney.

ADAM G. HILTON

1921 S. Fifty-seventh Street, Philadelphia, Pa.

Inspector of Airplanes and Airplane Engines, War Department, Equipment Division, Signal Corps, U.S.A.

Proposed by Hugh Lesley and Wistar E. Patterson.

LE ROY HILYARD

5722 Willows Avenue, Philadelphia, Pa.

Plant Engineer, Tioga Steel and Iron Company.

Proposed by Lewis H. Kenney and W. M. Boehm.

EDWARD MICHAEL MURPHY

1635 N. Fifteenth Street, Philadelphia, Pa.

Draftsman, Scientific Dept., Cramps Shipyard.

Proposed by H. T. McGaughan and J. L. Cozzens.

BENJAMIN ATWOOD SKINNER

1808 Chestnut Street, Philadelphia, Pa

Architect—Draftsman, United States Government, Navy Yard, Philadelphia, Pa.

Proposed by Lewis H. Kenney and W. M. Boehm.

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, Chairman

> *"From these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion; these dead shall not have died in vain."*—Abraham Lincoln.

Barker, Edward Williams, Sergeant .... Died March 17, 1918, Camp Meade, Admiral, Md.

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF MAY 25, 1918

NAME	RANK	CORPS	LOCATION
Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, H. Butler	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, via New York
Allen, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Anders, D. W.	Major	Company D, 502nd Engineers	American Expeditionary Forces, France
Andrews, J. H. M.	Major	Ordnance R. C.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
Asplundth, E. T.	Captain	103rd Engineers	Camp Hancock, Augusta, Ga.
Atterbury, W. W.	Brigadier-General	Director-General of Railways	France
Baker, W. D.	2nd Lieutenant	Aviation Corps	France
Banister, E. S.	Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Barnes, H. P.		Naval Flying Corps Mass. Inst. Technology	Cambridge, Mass.
Barnes, F. B.	Master Engineer	Headquarters Department 26th Engineers	American Expeditionary Forces, via New York
Bassett, F. H., Jr.		Officers' Training School	Camp Meade, Md.
Bear, H. K.	Lieutenant	Gas Defense Service	Camp Greenleaf, Ft. Oglethorpe, Ga.
Bell, Frank F.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
Bescherer, P.	2nd Lieutenant	319th Heavy Artillery	Camp Gordon, Ga.
Betus, A. J.		111th Infantry	Camp Hancock, Augusta, Ga.
Biester, W. H., Jr.	Corporal	"Co. E." 103rd Engineers	Camp Hancock, Augusta, Ga.
Bishop, A. B.		U. S. Radio School	College Park, Md.
Booz, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	Amer. Exped. Forces, via New York
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. F.	Lieutenant Engineer Officer	U. S. Naval Reserve Force	Submarine Base, New London, Conn.
Boyd, G.	1st Sergeant	Overseas Repair Section No. 1	Gas Defense Service, Medical Corps
Bradford, J. S.	Major	103rd Engineers	Camp Hancock, Augusta, Ga.
Bradt, Morris	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Bransome, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
Bream, C. C.	Corporal	103rd Engineers	Camp Hancock, Augusta, Ga.
Breen, J. W.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Brewer, P. C., Jr.	2nd Lieutenant	307th Engineers	Camp Gordon, Atlanta, Ga.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Britten, D. L.	Captain	Ordnance Officers' Reserve Corps	Inspector of Ordnance, Haddon Apts., Cleveland, O.
Broadhead, Alex.		19th Reserve Engineers	American Expeditionary Forces, via New York
Broderick, D. F.	Major	Ordnance Officers' Reserve Corps	Rock Island Arsenal, Rockland, Ill.
Brown, J. A.	Major	Ordnance Officers' Reserve Corps	Smithtown, L. I., New York
Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier-General W. W. Atterbury
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, via New York
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. F.	2nd Lieutenant	462nd Co. (Motorcycles), N. A.	Fort Myer, Va.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.		Carriage Division, F. A. Section	Washington, D. C.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Chance, T. M.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Childs, H. P.	1st Lieutenant	23rd Engineers	American Expeditionary Forces, France
Clark, J. W.		Russian Railway Service	Nagasaki, Japan
Cleeland, R.	Cadet Engineer	S. S. Neuse	Care U. S. Shipping Board

Colgan, R. J.	Captain	11th Regiment Engineers	Care of Adjutant-Gen'l, Washington, D. C.
Craig, Coulter	Captain	Ordnance Officers' Reserve Corps Supply Division	Office, Chief of Ordnance Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	Camp Hancock, Augusta, Ga.
Crowther, E. C.	1st Sergeant	Base Hospital No. 38	Second Regiment, N. G. P., Armory, Philadelphia
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Chamber of Commerce Bldg., Pittsburgh, Pa.
Cutler, James B.	2nd Lieutenant	319th F. A. R. C.	Camp Gordon, Ga.
Darlington, I. G.	1st Lieutenant	Gun Section, Production Division	Washington, D. C.
Day, R. F.	2nd Lieutenant	Aviation Corps	3rd Squadron, Ellington Flying Field, Houston, Texas
Derby, C. F.	Captain	Ordnance Officers' Reserve Corps	Camp Lee, Petersburg, Va.
Dill, C. M.		First Battery, Reserve Officers' Training Camp	Camp Lee, Petersburg, Va.
Donnelly, J. B.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Doyle, T. H.	2nd Lieutenant	U. S. Quartermaster's Corps	Overseas Service
Dunlap, V. R.	Lieutenant (Jr.)	Ass't Civil Engineer, U. S. N.	Naval Air Station, Pensacola, Fla.
Dunn, M. L.	Ensign	"U. S. S. Connecticut"	Care Postmaster, N. Y.
*Dyson, C. W.	Rear Admiral	Bureau of Steam Engineering, U. S. N.	Washington, D. C,
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.
Elcock, Chas.	1st Lieutenant	103rd Engineers	Camp Hancock, Augusta, Ga.
Farr, Roy S.	2nd Lieutenant	301st Engineers' Train	Camp Devens, Ayer, Mass.
Faust, W. D.		103rd Engineers	Camp Hancock, Augusta, Ga.
Fenton, Powell		Aviation Corps	France
Ferree, D. S.	Engineer Officer	Aviation Section, Signal Corps	M. I. T. School of Military Aeronautics, Cambridge, Mass.
Filbert, C. B.	Captain	41st Engineers	American Expeditionary Forces, France
Fish, W. N.	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Maryland
Forster, A. O.	Captain	Construction Branch Quartermaster's Corps, N. A.	Washington, D. C.
Frank, A.	Corporal	1st Replacement Regiment Engineers—Co. "A"	Fort Foote, Maryland
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	P. O. 717, American Expeditionary Forces, France
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gauthier, Jordan	2nd Lieutenant	56th Engineers.	Washington, D. C.
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Getz, Ralph P.	2nd Lieutenant	32nd Engineers	Camp Grant, Ill.
Gilbert, W. T.		21st Railway Engineers	American Expeditionary Forces, via New York
Gillam, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Goldsmith, H. F.		Naval Aviation Training School	Cambridge, Mass.
Goodwin, H., Jr.	Lieutenant	U. S. Naval Reserve Force	Bureau of Naval Officers' Operations, 1728 G St., N. W., Washington, D. C.
Gracey, A. L.	Private	Advance Ordnance Depot No. 4	American Expeditionary Forces, via New York
Graham, W. R.	1st Lieutenant	Aviation Section Signal Officers' Reserve	Aviation Mob. Camp, Camp Sevier, Greenville
Gravell, W. H.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Gray, B. D.	Major	Signal Corps, U. S. A.	Adams Bldg., Washington, D. C.
Gribbel, W. G.	Captain	30th Engineers, Gas & Flame Division	American Expeditionary Forces, via New York
*Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C.
Grossman, P. R.	Private	G. H. Q. Amer. Expeditionary Forces	U. S. M. P. O. No. 706, France
Gwilliam, Mark R. M.	Captain	21st U. S. Infantry	San Diego, Calif.
Hall, W. A.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	Co. "F," 32nd Engineers	Camp Grant, Rockford, Illinois
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hart, R. P., 2nd	Lieutenant	44th Engineers	Ft. Benjamin Harrison, Ind.
Hathaway, H. K.	Lieut.-Colonel	Ordnance N. A.	Washington, D. C.
Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
Heger, J.	Lieutenant	Engineers' Depot	Washington, D. C.
Henderson, S. D.	Private	304th Engineers	Camp Meade, Admiral, Md.
Henry, J. C.		Headquarters Dep't 19th Reserve Engineers	Amer. Exp. Forces, via New York
Hetherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Infantry	Charlotte, Ga.
Hollenback, E. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.	1st Lieutenant	Dental Corps, 28th Division	Camp Hancock, Augusta, Ga.
Houwen, W. P.	C. M. A. A.	United States Navy Air Station	Cape May, N. J.
Hulme, Norman	1st Lieutenant	458th Truck Co.	Fort Myer, Va.
Hunter, N. R.	2nd Lieutenant	47th Engineers	Camp Sheridan, Ala.
Hyland, G. N.	2nd Lieutenant	Aviation Concentration Camp	Camp Dick, Dallas, Texas
Jaques, J. D.	Lieutenant	U. S. N, R. F., Public Works Dept.	Navy Yard, Boston, Mass.
John, R. R.		Officers' Training School for Coast Artillery	Fortress Monroe, Va.

Jones, Jonathan	Captain	23rd Regiment Engineers	American Expeditionary Forces, via New York
Kennedy, J. H.		Aviation Section, Signal Corps	American Expeditionary Forces, via New York
Kent, S. L., Jr.	2nd Lieutenant	34th Engineers	Camp Dix, N. J.
Kern, F. X.	Lieutenant	23rd Regiment Engineers	American Expeditionary Forces, via New York
Klein, A. C.	Lieutenant	Production Section, Gun Division	Office, Chief of Ordnance, Washington, D. C.
Knbass, E.	Ensign	U. S. Submarine Base	New London, Conn.
Knight, C. C., Jr.	Lieutenant	318th Field Artillery, N. A.	Camp Jackson, S. C.
Koelle, W. F. B.	Sergeant	Signal Corps	Washington, D. C.
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	Amer. Exp. Forces, via New York
Laverty, C. R.		Co. "F," 305th Engineers	Camp Lee, Va.
Lawrence, G. E.	Lieutenant J. G.	U. S. Naval Res. Force	U. S. S. "Nokomis," European Waters, care Postmaster, N. Y.
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Levin, J.	2nd Lieutenant	Coast Artillery Reserve Corps	Fort Hancock, N. J.
Loeb, A. H.		154th Depot Brigade 1st Detachment	Camp Meade, Admiral, Md.
Lynch, N. H.		"F" Co., 6th U. S. Engineers	American Expeditionary Forces, France
MacGarrigle, G. L.	Private	Company "B," 103rd Engineers	Camp Hancock, Augusta, Ga.
Mager, J. W.	1st Lieutenant	446th Engineers' Pontoon Train	Washington Barracks, D. C.
Mahan, J. H.	U. S. Signal Corps Radio School		Columbia University, New York City
Mallon, G. J.	Lieutenant (Jr.)	U. S. Naval Reserve Force	U. S. S. "Mt. Vernon," care of Postmaster, N. Y.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Mardaga, L.	Ensign	U. S. Naval Reserve Force	Asst. Naval Inspector of Ordnance, Alloy Steel Forging Plant, Carnegie, Pa.
Martin, T. S., 3rd	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Mayburry, W. G., Jr.	Lieutenant	334th Field Artillery, National Army	Camp Pike, Ark.
McCausland, J. R.	Master Engineer Senior Grade		U. S. Post Office 701, R. T. O., American Expeditionary Forces, France
McClintock, J. L.		U. S. Navy Radio Station	Atlantic City, N. J.
McCord, J. B.	Lieutenant-Colonel	Ordnance N. A.	American Expeditionary Forces, France
McCormick, J. C.	1st Lieutenant	Engineer Officers' Reserve Corps	Amer. Exp. Forces, via New York
McCoy, J. F.	2nd Lieutenant	Aviation Section, Signal Corps	
McGarrigle, J. J.	1st Lieutenant	Anti-Aircraft, Artillery C. A. C.	American Expeditionary Forces, France
McMillan, H. L.	Major	Engineers	Camp Humphrey, Va.
Millar, E. A., Jr.	1st Lieutenant	Ordnance Officers' Reserve	Camp Hancock, Augusta, Ga.
Mohr, C. F.	Private	Co. "B," 45th Engineers	Camp Humphrey, Va.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Moon, T. E.	Corporal	119th Ordnance Depot Co.	Camp Hancock, Augusta, Ga.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Murphy, H. C.	Ensign	U. S. Navy	Room 6030, New Interior Bldg., Washington, D. C.
Meyers, W. C.	Captain	Ordnance Officers' Reserve	Inspection Division Standard Steel Car Co. Butler, Pa.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	1st Lieutenant	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixon-Miller, M.	Captain	Company "B," 501st Engineers	France
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
*Oakes, J. C.	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Orr, M. W.		First Battery, Officers' Training School	Camp Meade, Md.
*Otwell, Curtis W.	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Perry, Edward	Sergeant	Motor Truck Company No. 329	Camp Lee, Petersburg, Va.
Peterman, J. M.		Co. "G," 316th Infantry	Camp Meade, Admiral, Md.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pierce, D. T.		American Red Cross	France
Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Prichett, F. B.		103rd Trench Mortar Battery	Camp Hancock, Augusta, Ga.
Prince, H. W.		Squadron 80	Camp Eimerman, Fort Worth, Texas
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	79th Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	19th Reserve Engineers	American Expeditionary Forces, via New York
Reed, Thomas	Captain	Ordnance Officers' Reserve Corp	Inspector of Ordnance. Walter Scott & Company, Plainfield, N. J.
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Reninger, H. A.	Major	Headquarters, 103rd Ammunition Train, 28th Div.	Camp Hancock, Augusta, Ga.
Ridge, R. S.	Sergeant	23rd Engineers	Camp Meade, Admiral, Md.
Ridgway, J. J.	1st Lieutenant	Co. "F," 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.	Private	201st Aero Squadron	12 W. 95th St., New York City

Rogers, J. I.	Lieutenant	United States Naval Reserve Force	U. S. S. Helenita, in care of Postmaster, Fortress Monroe, Va.
Roop, J. C.	Captain	17th Engineers	France
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Russell, J. A.	Lieutenant	311th Engineers	Camp Grant, Rockford, Ill.
Sanville, L. P.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Satterwhite, R. L., Jr.		Company 20, Naval Aviation Detachment	Massachusetts School of Technology Cambridge, Mass.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	Washington, D. C.
Schaum, O. W.	Aeronautical Mechanical Engineer	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
Schoch, J. B.	Lieutenant	109th U. S. Infantry	Camp Hancock, Augusta, Ga.
Schoff, A. L.	1st Lieutenant	Signal Corps, Land Division	Fort Worth, Texas
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defense Service, Med. Dept., U. S. A.	Washington, D. C.
Scull, A. H.	Lieutenant	Railroad Transportation Corps	American Expeditionary Forces, via New York
Shallcross, J. B.	Lieutenant	Officers' Reserve Corps	1916 G St., N. W., Washington, D. C.
Sheahan, J. C.	2nd Lieutenant	Co. 11, Section B, Bldg. 6	Camp Jos. E. Johnston, Jacksonville, Fla.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Smith, A. H.	Sergeant	Utilities Detachment Quartermaster's Corps	Barracks B 104, Camp Meade, Admiral, Md.
*Smith, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	Overseas Service
Spillan, J. J. D.	Sergeant	Hq. 53, Brig. F. A.	Camp Hancock, Augusta, Ga.
St. John, Everett	1st Lieutenant	Coast Artillery Reserve Corps	Fort duPont, Delaware
*Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	Major	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Engineer Officers' Training Camp	
Thacher, C. H.	2nd Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
*Thomas, R. S.	Colonel	22nd Engineers	Camp Sheridan, Montgomery, Ala.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Corporal	Ordnance Detachment "B"	Gunpowder Reservation, Edgewood, Md.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Maine"
Truhan, L. J.		Reserve Officers' Barracks "B," Room No. 373	Naval Academy, Annapolis, Md.
Uhler, W. D.	Major	Quartermaster Corps, N. A.	Washington, D. C.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal
Vaughan, D. L.	Captain	Quartermaster's Corps N. A.	Camp Logan, Houston, Texas
Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Coast Artillery	Fort Greble, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces via New York
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	Engineer Officers' Reserve Corps	France
Webster, E. L.		Reconstruction Relief Work Friends' Unit of the Red Cross	France
Wentz, E. M.	Asst. Paymaster	U. S. Naval Reserve Force	U. S. S. Topila, care of Postmaster, N. Y. C.
Wheeler, G. C.	Private	Base Hospital No. 18	American Expeditionary Forces, via New York
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	Camp Hancock, Augusta, Ga.
White, J. A. Jr.	Private	Co. "A" 109th Infantry	Camp Hancock, Augusta, Ga.
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Wilkinson, R. W.		Engineers' Training School	Carnegie Institute, New York
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	Office of Inspector of Ordnance, U. S. A. Highland Park, Michigan
Wood, E. R. Jr.	Captain	18th Field Artillery, N. A.	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	Coast Artillery School	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Alex. Remount Depot, Macon, Ga
Zeckwer, J.R.	Ensign	U. S. Naval Reserve Force	Ship Inspection Office, Philadelphia
*Zinn, George A.	Colonel	District Engineers' Office, Custom House	Portland, Oregon

* Army and Navy member.

JUNIOR SECTION

DR. W. M. BOEHM, Chairman *Ex Officio* H. I. GOLDSTEIN, Chairman A. P. GODSHO, Secretary

THE monthly meeting of the Executive Committee was held at the Club House on Tuesday evening, May 14, 1918, Chairman Goldstein presiding.

There being no more regular monthly meetings of the Section, this meeting of the Executive Committee was devoted to a review of the work of the various committees, the chairman of each making a written report of the activities and results achieved by his committee during the past year and his recommendations for next year. These reports will be referred to the chairmen appointed by Mr. Kline next year and will give them an idea of the ideals and aspirations of this year's governing body.

The meeting was practically a review of the development of the section from a more or less unorganized body to one well organized, and the credit is due to the untiring efforts of the Chairman of the Section and his associates. All the meetings and other affairs of the Section were conducted in a manner of which many an older organization could well be proud.

The greatest difficulty was experienced in getting the junior members to attend the meetings, and while the average attendance was good, it was felt that more men should be present. The Social Committee did good work in attempting to make the meetings more attractive by providing refreshments in an endeavor to entice the " stay at homes " and the " go somewhere else " to be present. It was regrettable that sufficient funds were not available for a continuance of the lunches which were provided after the first few meetings. The outstanding social feature, however, was the Junior banquet held in February and was the most successful ever held by the Section. It gave the boys a chance to become better acquainted, provided a thoroly enjoyable evening, and if there had been any prospective Junior members present the work of the Membership Committee would have been easy.

Great credit should be given the Membership Committee for its Membership Campaign held during the year. Sixty new Juniors were elected, so that the Section now numbers close to two hundred. The Chairman in his final report makes a good suggestion and one which cannot receive too much publicity. He requests every Junior to submit the names of two or three graduate engineers who are working at their profession and having the necessary personal attributes to promote and continue the general good fellowship of the Junior Section. The Membership Committee will then efficiently investigate and recommend each application to the Senior Committee of the Club.

After a careful study of their records of attendance, the Meetings Committee has decided that the second Tuesday of each month seems to be the best evening for meetings and has decided if possible to retain this evening for next year. If this evening is known to be Junior Meeting night it will become an institution, and every Junior will know it is his duty to be among those present. If next year's Papers Committee equals the record of the present one, members will be well repaid for attendance at the meetings.

The Papers Comittee made a particular effort to have a well-balanced program of speakers and subjects, by having, as far as practical, papers on all branches of engineering. On some evenings two papers were presented, and as the speakers had all been instructed to make their papers reasonably short and concise, their presentation, together with the discussions, did not hold the meetings too late. The committee reports that it had a great deal of trouble securing speakers. First the inherent, false modesty of the engineer makes him refuse to speak when asked; second, a prospective speaker might be available one day and in the National service the next; third, some were not permitted by their employers to speak or were so limited in their remarks that a detailed paper would have been an impossibility.

Several times during the year difficulties were encountered, necessitating getting in closer touch with the Senior body. Accordingly the Club and Public Relations Committee secured an important piece of legislation in our favor, that is, contact with the Chairmen of Senior Committees, and direct representation at the Board of Directors' meetings when Junior subjects are under discussion. The effect of these rulings will be far-reaching and will enable us to do business with the executive bodies of the Seniors without the necessity of an intermediary.

SAFETY FIRST FOR FOUNDRYMEN

(*Continued from Page 300*)

recognized that here was a valuable discovery which offered a solution of the problem.

Leggings of special form having a wide cape or extension covering the foot were designed and ordered to be made of closely woven canvas by a large military equipment establishment. The first dozen pairs were received early in 1912 and were put into use in May. The laborers carrying molten iron were at first not ordered to wear these protectors, which were supplied free of cost, but they understood that if they neglected to do so and were burned on legs or feet they need not expect to receive pecuniary assistance which was freely given to the young man mentioned herein.

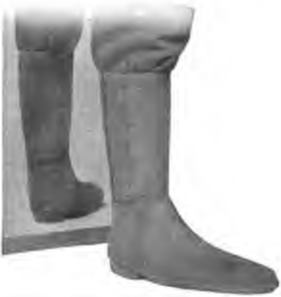

FIG. 2.—THE OUTERBRIDGE SAFETY LEGGING.

The protectors are, to this day, worn by all men carrying molten iron in the foundry.

Four years and eight months have now elapsed since the closely woven leg and foot protectors were first put into daily use, and there is yet to be recorded the first case of any man losing any time from burns on legs or feet from splashed molten metal while wearing the protectors, notwithstanding that molten metal has splashed over the protectors countless times. This is a truly remarkable record.

The President of Wm. Sellers & Company, Inc., in answer to an inquiry regarding foundry accidents from M. N. Alexander, Chairman of the Committee on Safety and Sanitation, National Founders' Association, West Lynn, Mass., wrote as follows:

"We shall be glad to coöperate with you by sending you copies of our Foundry Accident Reports in the manner you request. The burns were nearly all on feet or legs, due to splashing iron. For about a year past we have entirely eliminated burns of this character by insisting that the men shall wear canvas leggings which we provide. These leggings have a large cape which covers the boot well and the molten iron does not adhere to them. We have only had one pair of leggings at all injured in this way and the wearer was evidently saved from a severe burn."

Mr. Alexander at once sent an inspector to the foundry of William Sellers & Company, Inc., who said that he had visited numerous iron and steel foundries in various parts of the country, but that he had never seen or heard of any such canvas protectors. He photographed the men lined up at the cupola, all wearing the canvas leggings, and he also obtained a pair for a sample. Subsequently, Mr. Alexander brought out a design of leg protector, made of the same material, but minus the foot-covering cape; these leggings are intended to be worn with Congress shoes only.

(Illustrations courtesy of Wm. H. Horstmann Company)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS .·. PHILADELPHIA SECTION

Lewis F. Moody, Chairman. **John P. Mudd**, Secretary, Midvale Steel Company, Nicetown, Pa.

APRIL MEETING.

A DINNER meeting of the American Society of Mechanical Engineers was held in the green-room of the Adelphia Hotel on Tuesday, April 23. Mr. Lewis F. Moody presided.

Mr. D. Robert Yarnall acted as toastmaster, and introduced in order E. J. Cattell, President Charles T. Main, James Hartness, S. M. Vauclain, C. C. Thomas, and W. C. L. Eglin, who spoke on various subjects relating to industry and its part in the success of the war.

Ninety-three members and fourteen guests were present.

The following nominating committee has been appointed to name the officers for the ensuing year: D. Robert Yarnall (chairman), A. C. Wood, Coleman Sellers, Jr.

An election will follow by letter ballot. Selection very probably will have taken place prior to the time when the Journal reaches the reader.

DETROIT SECTION OF THE A. S. M. E. AND THE DETROIT ENGINEERING SOCIETY IN JOINT SESSION MAY 3, 1918.

Whereas, The demands of the country for men and means to fight the war has resulted in a deficiency of skilled workers in the trades and professions; and

Whereas, The women of this country could with a short period of training fit themselves to fill these positions as women have done in other countries at war; and

Whereas, Among the things which women could do advantageously are *drafting* and *tracing, inspection and testing of materials, both physically and chemically;* therefore

Resolved, That the Universities, Colleges and Technical Schools thruout the land be asked to consider the question of meeting this demand by providing special courses of instruction open to women students qualified to pursue such courses; and further

Resolved, That employers who could use such skilled help exert their influence with their Universities, Colleges and Technical Schools, and coöperate with them in developing and making available a great body of intelligent and adaptable women who are as eager and willing to serve their country as their brothers;

Thereby, Bringing about not only increased effectiveness in fighting the war, but also a greater mutual respect and saner relationship of our men and women.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

EASTERN PENNSYLVANIA CHAPTER

George W. Barr, President **George Boon**, Secretary

THE regular monthly meeting of the American Society of Heating and Ventilating Engineers was held at the Engineers' Club, May 9, preceded by an informal dinner. Dr. M. W. Franklin, who was to present a paper on "Spontaneous Combustion," being ill, the paper was read by Mr. A. P. Goldsmith.

This subject is quite an interesting one, and as Doctor Franklin's paper was really the first one ever presented on this particular subject, it is our hope some time in the near future to permit its presentation in the Journal.

This was our last meeting for the season. We will again hold meetings for the presentation of papers on the second Thursday of September.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS .·. PHILADELPHIA SECTION

Nathan Hayward, Chairman

H Mouradian, Secretary, 1631 Arch Street

JUNE MEETING

THE June meeting of the Philadelphia Section will be held on June 10 at the Engineers' Club. It will be devoted to the annual dinner. The result of the election of officers for the next year will be announced. It is planned to have some informal speech-making by several prominent engineers. Details are not available at this time, but will be given in a notice to be sent to the members before the meeting.

The May meeting was held on the 13th at the Engineers' Club. Mr. J. H. Anderton, of the American International Shipbuilding Corporation, read a very interesting paper on the Big Creek Plant of the Southern California Edison Company, with which Mr. Anderton was associated during its construction. The paper was profusely illustrated, many slides, in addition to their technical value, being of scenic interest.

The salient points of the development about which Mr. Anderton spoke may be enumerated as follows:

The use of Pelton water wheels under an extremely high hydrostatic head—2000′;

The difference in weight of generators and transformers of equal capacity made by the different electrical manufacturers;

The three-phase transmission line, 240 miles in length, with 150,000 volts between phases;

The use of 50-cycle frequency;

The employment of synchronous condensers at the receiving end to compensate for the leading power factor of the line itself;

The presence of local transients along certain sections of the line giving rise to high voltages sufficient to puncture insulators in those sections;

The relative immunity of the line to lightning trouble.

The paper was well received, a short outline of the main features of which was distributed to those present, contributing much to its enjoyment. The paper was discussed by Messrs. Anderton, Woodbury, Hayward, Mouradian and Sproule, and others.

TECHNOLOGY CLUB OF PHILADELPHIA

H. L. Walker, President.

N. A. White, Secretary, Wenonah, N. J.

THE Annual Field Day of the Club will be held at the Woodbury Country Club, Woodbury, N. J., on Saturday afternoon and evening, June 8, 1918. Members will take the 1.30 P.M. train at Market Street Ferry (Pennsylvania electric train). Members are invited to bring their families and friends. The afternoon will be devoted to a baseball game, relay race, tug-of-war and other games and stunts. The entire club-house and grounds are available for use of the members for the afternoon and evening. Supper will be served on the lawn and there will be singing and dancing in the evening. In order to cover expenses a charge of $1.00 for each Technology man and 50 cents additional for each guest will be made.

No meeting is scheduled at the Engineers' Club for June in view of the Annual Field Day to be held on June 8, and no meetings are scheduled for the summer months.

PHILADELPHIA SAFETY COUNCIL

LOCAL SECTION No. 7 OF NATIONAL SAFETY COUNCIL

J. F. CONNER, President

J. P. MUDD, Secretary-Treasurer,
The Midvale Steel Co., P. O. Box 1322

APRIL MEETING.

A MEETING of the Philadelphia Safety Council was held at the Engineers' Club on Monday evening, April 22.

The meeting was preceded by a well-attended dinner held in the new dining-rooms of the Club. About forty-five attended the dinner.

Mr. C. F. Conner presided at the meeting.

The subject, "The Woman in Industry," was opened by a short talk by Mrs. Samuel Semple, of the State Industrial Board. A discussion followed, in which the following participated: Mr. J. F. Conner, United Gas Improvement Company; Mr. J. B. Douglas, United Gas Improvement Company; Mr. Townsend, Hoopes & Townsend; Mr. Calvert, Chester Paper Company; Mr. C. C. Black, Department of Labor and Industry; Mr. Wolf, American Pulley Company; Mr. C. Howard Williams, American Pulley Company; Mr. Williams, Strawbridge & Clothier; Miss Binns, Miller Lock Company; Miss Roadefer, Philadelphia Rapid Transit Company.

Fourteen new members were admitted.

MAY MEETING.

On Tuesday, May 14, at 1 P.M., the committees of the Philadelphia Safety Council met at a luncheon at the Engineers' Club. Messrs. J. F. Conner, Donald N. Frazier, C. C. Black, L. J. Freund, C. Howard Williams, and John P. Mudd were present. Mr. F. M. Rosseland, one of the secretaries of Chicago, was present and went over several matters of vital interest to the Local and National Councils. Among the subjects discussed at the conference were: The advisability of having a paid secretary; the means of financing such an undertaking; the holding of separate meetings for workmen and executives; and several other matters of minor interest. No decisions were reached, but Mr. Rosseland brought many new thoughts from his association with the Chicago Section, which will undoubtedly be used during the coming year.

WORCESTER TECH CLUB

GEORGE A. DENNY, Chairman

ROBERT M. BARR, Secretary, Land Title Building

SPRING OUTDOOR MEETING

SHAD dinner at 6.30 P.M.—$2.50—Tinicum Inn, Essington, Pa., June 12, 1918.

Leave Engineers' Club 4.00 P.M. Visit either Westinghouse or Hog Island Plants on the way.

Come and make the day a success.

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-7 JULY, 1918 NO. 164

ADDRESS[*]

By HONORABLE WILLIAM HOWARD TAFT.

THIS Convention speaks an irrevocable public opinion that the war must go on until our foe is defeated. We are fighting the German people led by the Hohenzollern Dynasty, its Military Hierarchy and Prussian Reactionaries. They maintain the undiluted and cruel doctrine that " might makes right." They have been strengthening their might for fifty years in order to establish their right to the domination of the world.

Courtesy Public Ledger

HON. WILLIAM HOWARD TAFT
PRESIDENT, LEAGUE TO ENFORCE PEACE

Since August, 1914, no solution has been possible, consistent with permanent peace, except a victory of the Allies. The utter untrustworthiness of the Kaiser as a signatory to a treaty of peace makes his continuance in power a continued threat against the integrity and safety of other nations. When there was a deadlock on the eastern and the western fronts, some hoped that real peace by negotiation and without victory could be achieved. Store was set upon proposals and counter-proposals contained in official statements as a means of reaching a common ground for negotiation. Such optimism was not justified. Nothing but an inconclusive German-made peace could have resulted. What should have been clear then, has been demonstrated since by Germany's action in Russia, Rumania and Turkey and her attitude in her western drive. Thru the insidious and treacherous propaganda of German socialists in the pay of German militarism, the poor, ignorant Russian people were led into Bolshevikism, the destruction of their army, their only means of resistance to German conquest. They were like the lamb, pleading with the wolf, and the end was not doubtful. The Germans now divide Russia up into States, called independent but subject to the German control. Rumania has been despoiled of much that was hers and has become a vassal state. The Germans make peace with peoples but continue the war against them. The cruel measures of suppression to which the various Russian peoples have been subjected by the brutality of their German conquerors we dimly hear. The Armenians have been turned back to the Turks. The one sympathetic associate in Teuton cruelty among the countries of the world, the Turkish Sultanate, has thus been restored to its bloody rule over its Christian victims. The initial success of the German arms on the western front, as two millions or more of men in mass are hurled at our devoted allied line, calls out the real truculence of the controlling element of Germany. We hear now of indemnities and annexations previously eliminated.

No one in the wildest flight of his imagination now can think of undefeated Germany yielding either proper indemnity to Belgium or justice to Alsace-Lorraine, each of which Great Britain and the United States have made a *sine qua non*. Nor will the unconquered German ruling class consent to lift the German paw and remove its crushing weight from prostrate Russia, or give over to decent rule the blood-stained Christian provinces of Turkey. If the wrongs of Belgium, and Alsace-Lorraine, and of Russians, Italians, Poles, Armenians and Serbians and other Slav peoples, are not righted, the war will have been sacrificed for nothing. We must, therefore, conquer the Germans if a just and lasting peace is to be secured.

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[*] Delivered at the Convention of League to Enforce Peace, Thursday morning, May 16, 1918, Philadelphia.

Therefore, the slogan of the Allies, and the cry of this country, must be "Victory with Power."

It must be declared by our Congress. Its sincerity must be shown by deeds. We must spread upon our statute book a plan for the massing of a mighty force and putting it on the soil of France, a force so great that its mere presence there will insure victory. This means time for preparation. We are a peace-loving people. We have been a peace-loving nation. We have been slow to prepare in the face of events that should have taught us to act earlier. But this is no time for vain regrets. It is a time now for action. We act by legislation. We act thru our National Congress first, which declares a plan, and then thru our Executive, who carries out the Congressional plan.

Thank God, the will of the people to see this war thru to German defeat is gathering with irresistible force. Those who represent us in the National Legislature and in the Executive must know, and must be made to know, that only one policy will be tolerated, and that is war to the top of the capacity of the country. At least 5,000,000 of fighting men must land in France from this country to attain victory. We may need millions of auxiliaries. Let us have it known to the world; let us have it heralded in London and in Paris to hearten our Allies; let us have it sounded in Berlin, that all the energy of this country, all its potential power, is to be converted into force. We are hurrying troops now to stay the Germans on the western front, but let it be known that this is only to help hold the line until a greater American army insuring victory can be put there. It will take fully two years—perhaps three—to fulfil proper plans of preparation. We should face the facts. We should realize what is before us. We should discard unjustified optimism. We should set our faces stern and unbending for but one purpose—"War, War, War!"

Words like these may sound strange in a gathering whose purpose is peace; but those who would say so, do not see the fact. Our Society was organized to make this war an instrument for the promotion of peace. It holds that the horrors of the war and the awful misery it involves must make the nations bind themselves to a common obligation for the future to suppress war. We call for a primitive political organization of the world, affording judicial and mediating agencies and an international police to stamp out the beginnings of every riot of world violence. A member of the family of nations which looks upon war as a normal means of acquiring power and a justifiable condition of growth, destroys hope for the future. Such member must be whipped into a different view, and into conformity with the public opinion of the world. Nothing but force can cure the brutality and ruthlessness of force. In such a case the maxim, "*Similia similibus curantur,*" has full application. The peaceful countries of the world are obliged to change themselves into the habits, the sacrifices and the panoply of war. When they, in spite of their lack of preparation, in spite of their peace-loving instincts, shall strike down in battle a people that makes war its god, their cure will be complete, the scales will fall from their eyes, and with a clearer vision they will see that he whom they have ignorantly worshipped is the devil and not God. Until so cured, they can never be an amenable and law-abiding member of a peaceful world community.

For these reasons, we pretermit in this meeting discussion of the particular treaty terms to effect our purpose in the proposed political world organization. We of this League, who are the most peace-loving people of this most peace-loving nation, now that the independence and liberty of the world are at stake, and its permanent peace is attacked by brute force, have drawn the sword and have thrown the scabbard away. Let us have Peace, but let us have War, that we may have Peace.

ADDRESS*

By CHARLES T. MAIN

PRESIDENT, AMERICAN SOCIETY OF MECHANICAL ENGINEERS

I THOUGHT that possibly you would like to hear of one of the problems, at least, put up to the Presidents of the various National Engineering Societies and other organizations by the Government, and so I will speak about a problem which was given us a short time ago by the then Cantonment Division, now the Construction Division, of the Army.

A few weeks ago the Presidents of the American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Architects, President of the United States Chamber of Commerce, the President of the Building Contractors Employees Association of Chicago and President of the New York Association of Contractors and a representative of the American Federation of Labor were invited to come to Washington to pass on the form of contract which should be used in carrying out the vast program of the Construction Division.

Before war was declared the construction work for the Army was done by the Construction and Repair Branch of the Quartermaster-General's Office. When war was declared the Cantonment Division was formed with one Colonel, two Captains of the regular Army and one Major of the Reserve Corps. Very soon there was put up to this division the problem of providing housing for about a million troops, and it was required that this housing should be ready in about three months. It became necessary rapidly to build up an organization for planning this work. The Committee on Emergency Construction, with the assistance of contractors, engineers and architects, formulated the Emergency Construction Contract. This contract was used for all of the construction work for camps and cantonments and for other construction work which the Cantonment Division has done.

The work had to be let to the various contracting firms of the country. In spite of the small beginning of that organization they built up their own organization. The contracts were let and the housing was ready for the men practically as soon as the men were ready for the camps.

There were first planned thirty-two cantonments, with the idea that the company formation contained one hundred and fifty men. Before work on the plans had proceeded very far, however, the orders were to change the company formation to two hundred and fifty men. After the plans were well along the number of cantonments was reduced from thirty-two to sixteen. It was estimated that each cantonment would cost about $6,000,000. After the work was nearly all done, many changes were ordered, which increased the cost to about $9,000,000.

They thought, and I believe they were right, that they could not have let the contracts for that work, with its varying changes of character and scope, under any other system except the emergency contract, which was cost plus a per cent. with a fixed outside sum.

Before the cantonments were completed this Division was given charge of all the other construction work on this side of the water, and the program now amounts to about $1,300,000,000. There are perhaps three hundred jobs, varying in size from a few thousand dollars to $45,000,000.

One job was started for the Ordnance Department with an estimate of a few hundred thousand dollars. Before it had proceeded far, several hundred thousand square feet of floor space was added for the carriage department, and before it had proceeded much farther, orders were given to add a cantonment for five thousand troops. All of these changes required radical changes in the plans.

In another case, after the work was well along and several thousand men working, orders were received to stop and the work was all stopped for several weeks, and then started again with many serious changes ordered. These examples illustrate how little is known of the eventual scope of the work at the start.

There has been some criticism of this form of contract against the advisability of using the Emergency Construction Contract, and many people thought that possibly there might be some other way of doing this work. For that reason the Committee which I spoke of previously was called to Washington and asked to pass on a form of contract under which this emergency work might be done.

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* Delivered at Dinner to the Council of the American Society of Mechanical Engineers, under the auspices of the Philadelphia Section, April 23, 1918, Hotel Adelphia, Philadelphia.

There are, generally speaking, two methods of doing the work. The first one may be called the purchase and hire method, under which the Government purchases all the materials and hires all the labor. To do this it would be necessary for the Government to build up an immense organization in Washington, which would become very unwieldy, and the work would eventually have to be decentralized in order to be carried out. The time required for building up this organization would be so long that the Committee decided that that method of doing the work should not be used at this particular time. There may be occasions, in time of peace, when some colossal project is under way when such a method might be proper or even necessary, where sanitation, policing or other Governmental functions could not otherwise be provided.

The second method for doing the work would be under one of the various forms of contract, such as the lump sum contract, which has been used more than any other type in this country, especially up to within the last few years. With this form of contract it would be impossible to start on any of the work until the plans and specifications are all prepared and bids are in and the contract awarded, and there would be a loss of time which might be vital to the project.

Another form of contract is the lump sum with percentage allowances, or some other allowances, for additions; but the same objection holds to that form as to the lump sum contract.

Another form is letting the work on a unit basis, such as a yard of concrete or a ton of steel, but there it would be impossible to form any intelligent idea as to what the unit price would be, because it could not be foreseen what the character of the work would be, where it was to be done, how many additions, or how many changes were to be made, and therefore the Committee decided that that was not the proper form to use.

Finally we came to the form of contract which has been called the Emergency Construction Contract, under which the contractor receives a percentage of the cost, the percentage diminishing as the cost of work increases, with a fixed sum at various intervals. Under this form of contract the work can be started immediately, and it will allow the Government or any Department to make any changes which are desired in the scope of the work. The percentages are so small that it seems to be a fair thing for the Government. There can be no excess profit under this form, as the price of labor and materials is fixed by the Government. The Committee reported that in its opinion the Emergency Construction Contract was the proper form to use, and the report was transmitted to the Acting Secretary of War.

The constitution of the Society prevents the Society from doing things in a public way which it might do, and which perhaps would prevent the President from doing certain things that he might do, and in times of peace the letter of the constitution should be lived up to, but it seems to me that in these times we cannot stand too rigidly on technicalities, for action must be taken immediately or else it is of no use, and I hope that your President will not be so indiscreet as to cause any reflections to be cast upon the Society, and I hope that if any problems are put to him, not as a person but because he represents the Society, that those problems will be solved in a way that will be satisfactory to the members of the Society.

There is one other problem which came up the other day, which was rather interesting. The National Industrial Conference Board, composed of a great number of national industrial associations of the country, was very much exercised because the House of Representatives had just passed the Naval Appropriation Bill with a rider attached to it, which prohibited the payment of cash bonuses, or the use of time studies, or any of the efficiency methods on any work done under that appropriation. Such action would not only prevent any work of that sort being done in the arsenals, but it would also prevent any private concern that was doing work for the Government to receive any of that appropriation it had in operation, unless it abolished efficiency systems. I think that most of us feel that if those systems were properly applied they do assist in speeding up production. If there is one thing that we ought to do in this country now, it is to speed up production, and anything that is done to cause it to be diminished should be frowned upon.

The National Industrial Conference Board thought that the engineers, whose reports are looked up to as being unprejudiced, would be the proper people to send a resolution to the Senate protesting against the passage of a bill of that sort. Representatives of the National Societies were invited to attend the meeting of the Board, and we in turn invited the Chairman of the Board to meet with the Engineering Council. The Engineering Council appointed a Committee to draw up resolutions. These resolutions have been sent to the Senate, Committees on Naval and Military Affairs and several others.

As I said before, in a way we may be doing something in the Societies that perhaps we have not any right to do, but if anything is to be done, it must be done quickly.

ADDRESS[*]

By SAMUEL M. VAUCLAIN, Member

VICE-PRESIDENT AND GENERAL MANAGER, BALDWIN LOCOMOTIVE WORKS
MEMBER OF WAR INDUSTRIES BOARD

THE reason of my coming here and why I have with me a few of our representative engineers is that I believe that our success in this war will depend upon engineering ability to cope with the enemy. The country has been living in a fool's paradise for many years. Every obstacle that could possibly be placed in the way of big business or large engineering schemes has been placed in the way by the so-called people of the United States or their political representatives. On the other hand, in Germany the prime ruler of Germany with all his millions has compelled the people of Germany to exert themselves to the utmost to develop, extend and perfect their engineering and everything pertaining to the manufacturing arts. The result of such training has already been seen. We have had nearly four years of it, but now that the American people have embarked in this enterprise we will show this gentleman that we have skill on this side of the water that can be developed and matured in far less time than it required in his country.

I listened to Mr. Cattell. I have known him for more than a year and have always respected the great knowledge he has of this city, and am always glad to listen to his statistics, and I am also willing to admit that Philadelphia is a veritable Sleepy Hollow. Nothing runs thru Philadelphia. That has been decided many years ago, and it is a good thing that nothing runs thru Philadelphia. It seems to me that anything that is of any real use to this country stops in Philadelphia and stays here.

I wish to call the attention of engineers not exactly to the present status of this country, but to what is going to happen in the future, after this war has been won by the United States. I also wish to call your attention to the present condition of the industries of this country. They are famished and they are called upon to support this Government in one of the most gigantic wars that the world has ever known or ever will know. This war will be decisive as to wars, and will demonstrate the uselessness of such conflicts at least for several centuries to come. Beyond and ahead of everything else we are engineers and are responsible more than any other class of people for the pre-eminence of this country in the future, and therefore I suggest that in the coming elections which are sure to come this or next year that in choosing your candidates for responsible positions you choose the men who have a capacity for business, and who understand what big business is, and who will devote at least one-half of their energies to the perfection and permanent establishment of large industries in this country. Now, why do I say large industry? Because, without a large industry nothing can be done. Nothing can be accomplished any more on the scale which we require unless we have large industries, and how are these large industries consummated Not by individual ownership. Not by the old system of copartnership under which I grew up and in which I prospered, but it is a business of the people; the capitalization of these large industries is placed in the market and the people purchase, and the people have a right to a fair return upon their money, and we who are their representatives and employed to handle these great industries must see to it that the owners of our establishment are fairly compensated for the use of their money. For the last five years it has been almost impossible for large industries, excepting probably one or two, to make a proper return to their stockholders for the money which they are using in those industries. Such a condition must not now continue, nor must it be maintained in the future. If it is maintained our mechanical and commercial supremacy which we will attain by the end of this war will pass to the other side of the water, and we will be lost and be at their mercy.

Shortly before the war I visited Germany, and being somewhat of an observer I noticed the almost maniacal effort that was being made to construct double lines of railway tracks paralleling those already existing. At once I concluded that war was imminent. I went immediately to England and told some of our railroad friends, at least one who had just ordered some locomotives to be constructed in Germany. I said, "Why is it that you cannot ask those of your own flesh and blood to build your locomotives, who live across the water, under the American flag, and who are closer to you in every way, instead of patronizing the Germans on the other side of the Channel, who will take your money and use it to annihilate you in the near future?" He said, "I cannot believe it." I said, "At this time preparations are under way that mean nothing but war, and you are to be the victim."

Immediately after the war broke out I returned to England and paid this gentleman a visit. He took me by the hands and said, "You have told me the truth. We have lived in a fool's paradise. We are at their mercy, but if you don't mind hearing it, I have just received those locomotives and I have the money, too."

Consider another illustration of the large industry. We had a small rifle plant capable of making rifles up to sixteen inches in diameter, in the village of Nicetown—or probably it might be called Philadelphia—that was recently purchased by a syndicate, and to that plant was added several other steel plants—plants of great magnitude—and what is the result? The result is that this plant has a financial backing that is second to none in the world, and to-day this plant in Philadelphia is the only plant in the United States of America that is delivering its guns and its ammunition on time. Without this financial backing, created by a large industrial organization, or an example of large business, this thing could not be accomplished.

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[*] Delivered at Dinner to the Council of the American Society of Mechanical Engineers, under the auspices of the Philadelphia Section, April 23, 1918, Hotel Adelphia, Philadelphia.

Another less important enterprise has existed in this city for eighty-five years or more—the principal business of which is constructing locomotives. This little plant is now turning out locomotives of various kinds—steam, electric and gasoline—at the rate of about one hundred and twenty million dollars' worth a year. As many as *one hundred* locomotives have been turned out in *one week* during the past winter.

On the banks of the Delaware, the United States Government is dependent upon an industry started by this locomotive plant now operated by this other industrial fabric which has been created in this city—the Midvale Steel and Ordnance Company—and 60 per cent. of the rifles this country is using comes from this plant on the Delaware.

At almost the same point on the same Delaware River ammunition is being manufactured both by day and by night. The women of that section of the country are as active as the men, and large amounts of this material are being shipped.

In the southern portion of this city an old, long established plant that has gone thru the vicissitudes of life—mechanical and industrial—several people have faded away from the face of the earth in an effort to make this establishment pay, and it is now quietly running day and night, turning out monthly at least one million dollars' worth of the most desirable machinery that this Government requires for war purposes.

Up the State, in a little valley where I was told I would never get a man to go to work, and where a few years ago 175 men were employed, 6000 men now labor for Uncle Sam in producing gun forgings and other forgings most necessary to the transportation service of this country, and which, in Washington, are now being considered of even greater importance than artillery and ammunition.

Without organization, without large business, without an immense army of brains at command, none of these things could be accomplished. On Thursday morning, early, before the people of this country or this section are aroused, there will quietly move out of the shops on the Delaware River the greatest engine of artillery that has ever been constructed in the United States or any other country, and constructed in the short space of time of less than ten weeks. This is Philadelphia engineering, this is Philadelphia enterprise, altho fast asleep, but it is due to big business. We must have big business. Had it not been for the United States Steel Corporation, for the magnificent engineers which they threw, without charge, into my service in connection with this matter, this engine of warfare could never have been created. The side girders for the machine only weigh seventy-five tons(!), and to be constructed, the material rolled in the mills, and transported and landed at Eddystone for final completion in six weeks, is a feat that never could have been accomplished if we had not had a large organization.

In Washington it has been my pleasure to create, or to advise the creation of, additional supplies for forgings and for finished guns. The hard winter we have gone thru has delayed every manufacturer, not only the machine tool builder and the forge man, but the finisher; but that delay is slight; it will soon be overcome.

All this talk we hear of profiteering is idle chatter. When a man comes to see me in Washington and speaks of patriotism I say, "Now, stop. Every citizen of this country is as much a patriot as you, and every man who treads this earth on this side of the water is a patriot, even if he does not know it, and ultimately that knowledge will come to him." I am not afraid of profiteering. The only thing I am afraid of is that in the attempt to shine before the country, in the prevention of profiteering many of our manufacturers may be deprived of a price that will enable them not only to put their best efforts into the production of the material we so much need, but enable them to be somewhat extravagant in the production of that material. At Hog Island where we are going to build ships and where we are going to have the greatest shipyard that the world has ever seen, we have heard all sorts of stories, articles in the newspapers, regarding profiteering and extravagance and everything of that sort. Everybody who has been in big business and who has paid the bill himself will know and will understand that you cannot do in five minutes a thing which ordinarily would require a day unless you are extravagant; unless you are willing to part with your gold to see the thing grow rapidly and be ready for use. It is immaterial what we pay for labor. We must pay the laboring man enough to have him satisfied. He must be happy. We cannot go into the detail of what it costs him to live. That is *his* business. Let him look after that. I am always reminded of the story of the mate aboard the ship. He had charge of the bow of the ship, and one day they got into shallow water—eight fathoms—and he made a rush for the cabin to see the captain. The captain was busy entertaining a couple of ladies in the cabin and did not want to be disturbed, but he asked for the report and when the mate said eight fathoms he said, "Return to your end of the ship, sir. I am captain of this ship." The mate returned to the end of the ship and immediately heard that they were in seven fathoms. He rushed back and reported seven fathoms, and he was immediately ordered back by the captain to his end of the ship. When six fathoms was called he ordered the anchor dropped. He went back to the captain, saluted him, and the captain looked at him and wanted to know what was the matter, and he said, " My end of the ship is at anchor, sir. You can do as you please with yours." We want to look after our end of the ship and we also want to take it for granted that the other fellow is looking after his.

There is nothing so harmful in time of war as criticism. There is not a man in this room who cannot be criticized. I will venture to say that if you gentlemen were so disposed you could sit here all night and criticize me. That is what is going on with some few people in Washington. Take the Ordnance Department, for instance. It is the most criticized department in Washington; and why not? There is a great, grand, good reason for that Ordnance Department to be criticized, and they deserve it, because there is no other department there to criticize. They are doing all the work. They are trying to get this great machinery ready in the shortest possible space of time. Some of the best men in the United States are there, and there are a few people in Washington who are not the best men in the United States, and it is those who are not the best in the United States who are the most prominent and loud-mouthed in their criticism of people working day and night to discharge their obligation to the people of this country, and many of them without compensation therefor. In connection with this subject of criticism I am reminded of my predecessor, Mr. Charles T. Parry. He was our philosopher. He was not only my philosopher but my friend and guide. Once he said to me, " Sam, never discharge a man because he does something wrong or because he is no good in certain respects, because if you do you have got to get a man to replace him, and," he said, " when you get this fellow to replace him you will find that he has just a few more faults than the other fellow had. So you will make better time if you make a study of this man and correct his faults, because he does know something about your business. Now," he said, " I had a close shave once. When I was chief draughtsman I got the magnificent salary of $7.50 a week, and as time went on I made up my mind that I wanted to get married, and I went to Mr. Baldwin and I said I want to get married and I want my wages raised. He said, ' Charles, how much do you want? ' I said, ' I want $15 a week.' Mr. Baldwin said, ' Oh, I cannot do that; that is twice as much as you are getting.' He said, ' I will give you $9 a week.' ' No,' I said, ' that won't do. If you cannot do any better than $9, I will wait until I am worth $15 and then I will get married.' So I went off to my work and the next day Mr. Baldwin sent for me and he said, ' Charles, I want to have a serious talk with you.' ' All right, sir.' ' I have been talking to Mr. Hufty about you '—he was the superintendent—' and he says you are not very well thought of.' " Mr. Parry said, " ' Is that so? ' ' Yes.' ' Well, what is the matter? ' ' Well,' he said, ' Mr. Hufty says that you make more mistakes than any man in this plant.' ' Well,' I said, ' Mr. Baldwin, I guess that's so; that is so; I will admit that.' Then Mr. Baldwin asked, ' Charles, what is the reason for all this? ' ' Well,' I said, ' Mr. Baldwin, there isn't anybody else to make them, consequently I make them all. I make all the drawings and I measure all the sticks.' " In those days we did not have any templets or gauges or anything of that sort. A man, in boring out a wheel center, in turning out the inside, took a long stick and the draughtsman marked the distance on it and put a notch in it with his knife, and that was his gauge. So his reply to Mr. Baldwin was that he made all the mistakes because he did all the work, and Mr. Baldwin said, " All right, Charles, your wages will be $15 a week." Now, I am willing to pay any man that works for me the absolute maximum amount of money that my directors will permit me, if he makes all the mistakes of that plant, because if he makes all the mistakes I will know he is handling pretty nearly all the work and he is my best man, and in proportion to the number of mistakes a man makes in the ordinary course of manufacture you can safely depend upon it that he is proportionately interested in his work.

I thank you, gentlemen, for giving me this opportunity to express my views as to the preservation of big business. I think it is the most important thing to be considered. The war is nothing to that. We can whip the Germans. We can be successful in this war, but if the industries of this country and the engineering business of this country are going to fade away and go into the hands of people on the other side of the Atlantic, the war will have been useless and we will practically be lost.

This little industry of which I spoke to you on the banks of the Delaware is only one. Pennsylvania to-day is manufacturing one-sixth of everything that this country needs for this war and maintaining her commercial requirements. Pennsylvania has the only plants in this country for the manufacture of large guns, at Nicetown, Bethlehem and Midvale. In this vicinity we have the largest textile industries of the world, the largest small-arms factory in the world, the largest separate shipbuilding industry in the world. We are pre-eminent, and yet from Marcus Hook to Bristol there is not a banking institution in this city that has the slightest idea of what is going on. A few days ago I had the opportunity to discuss this question with some bankers, and I said unless we have bigger banking institutions in Philadelphia the manufacturing interests of this city must go to New York, and Philadelphia and its merchants will lose out. We must have banks in Philadelphia that can lend you more than a paltry $500,000. Five hundred thousand dollars is only the payroll for one shop; and if a plant, one shop doing a business of $10,000,000 a month, has its collections postponed by any accident, where is it going to get money to continue its business for another month until these collections can be met? It is impossible. And therefore we must not only have big business in the manufacturing line but in the commercial and financial lines, so let us come up to the example set by big business and see that the stockholders are enabled to get a profit thereon.

ADDRESS*

By CARL C. THOMAS

DIRECTOR, MACHINERY DIVISION, AMERICAN INTERNATIONAL SHIPBUILDING CORPORATION

I AM very glad indeed to have this opportunity to speak to you, because I want to make one or two suggestions as to how mechanical engineers can help in the work of building ships. It is with the greatest pleasure that I have heard Mr. Vauclain speak as he did about the difficulties and responsibilities of putting thru large enterprises in quick time. The best answer to the critics of the work of shipbuilding at Hog Island or the work of building the yard is obtained by arranging for those who make the criticisms to go down and see what has been done. Undoubtedly mistakes have been made. No such proposition can be put thru—an island swamp cannot be turned into a shipyard employing 25,000 men within six months, without some oversights. Some of the technical heads of that business enterprise I was associated with in shipbuilding work twenty years ago. I know them to be exceedingly able engineers, and I believe the work is going steadily ahead and that a large number of ships will be rapidly turned out at that yard.

Engineers have more to think about now than they have ever had before. They have been called upon, and are being called upon, to " deliver the goods " in preparing this country and in helping other countries to fight. We have more to talk about but less time to talk and prepare speeches.

We have a new word in engineering, and it is about that word, or its application, that I want to speak—the word "fabrication."

At the present time a very large number of ships have been sunk—they tell us some eleven or twelve million tons. I do not know whether that means gross tons or dead-weight carrying capacity, but at any rate a tremendous quantity will have to be replaced. After the war there will be tremendous quantities more to be built, and they will very largely have to be " fabricated," that is, the component parts will be made at distant points and brought to the yards for assembly into ships. Heretofore the marine engineering work of the country has been chiefly done on the coasts. At the present time it is being done largely inland; that is, the fabrication of material for both the hulls and the propelling machinery is being largely done at inland points, such as Kansas City, St. Louis, Indianapolis, etc., etc. The Minneapolis Steel Company is making a large number of deck winches. Windlasses are being made at Chattanooga, Tenn. Rudders are being made in Kansas City, Pittsburgh, etc. Rudder stocks are being made in Cleveland, and 6000 tons of marine shafting are being made at Pittsburgh for the Hog Island ships. I could mention a great many concerns that have never done marine work before that are now making strictly marine appliances. There is no black art about the marine business. Engineers from all over the country are coming forward in a perfectly magnificent way and filling shops with the work for this specific purpose of driving ships. But the shops of the country that are doing this work are rapidly becoming filled to their capacity. There is not now in the country nearly enough equipment engaged in producing propelling machinery and deck fittings and hull fittings. We shall have to produce more than we think we have the capacity for producing at the present time. There are on order at Hog Island 180 ships—110 of them are 7500 ton dead weight carrying capacity; 70 of them are of 8000 ton dead-weight carrying capacity—and these ships are from 11,000 to 13,000 tons displacement. They are in the neighborhood of 400 feet long for the 7500 ton ships and 450 feet long for the 8000 ton ships. The ships are all to be driven by steam turbines. The capacity of the steam turbine shops of this country—those capable of turning out geared turbines which are necessary for merchant ships—is all taken up for the next two years. We shall have to depend, in much of the shipbuilding program, on our old friend the reciprocating engine, and it will be no mistake to go back to that form of well-tried-out engine. The economy will not be so good as with the geared turbines, but all things considered it is a very good machine, and there are more shops which can help turn them out than can make geared turbines.

To go back to this word " fabrication "—we are all called fabricators at Hog Island. One man came into my office for a job and he said he was a good man on piping, but that he had applied to one of the other departments some time ago and had not been taken on. He said: "The man there asked if I understood fabrication. I told him I did. I have been waiting for a long time to hear from him, but he has not sent for me to come, and I have since understood that fabrication means lying, and I fear he has a wrong impression about me." But, for lack of a better word, we speak about "fabricating" engines and ships and all the parts that go to make the ships. This will have to be done in shops thruout the country. Cylinders have to be made somewhere for marine engines; propellers, somewhere; drop forgings have to be made in a great many places; thousands and thousands of valves have to be produced of all sizes, from very small up to very large valves; and so I could go on and enumerate things that have to be provided.

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* Delivered at Dinner to the Council of the American Society of Mechanical Engineers, under the auspices of the Philadelphia Section, April 23, 1918, Hotel Adelphia, Philadelphia.

We have found in our experience of the last six months in placing orders—many million dollars' worth of parts that go to make up these ships—that the engineers of the country are eager and able to come to the rescue and make parts which, in many cases, they have never made before, and never saw or knew anything about. The country is depending upon shops wherever there is equipment that can be turned to making engines. There are great possibilities for such shops to be useful, and there are people who can design the parts, and put such directions on paper as will enable the shops to turn out the work.

The steel is coming now. It seems probable that we shall get steel very fast and very soon. The propelling machinery is coming along for 120 ships. The orders now on hand for 60 additional ships must be provided for in some different way, because the shops are up to their full capacity at the present time. In many cases the shops which are turning out parts for the ships can also go on after a reasonable time and duplicate those parts for the new ships, but there are many cases in which that is not practicable. The present equipment of certain shops must be doubled or trebled. In some cases where shops have been inadequate but have an organization capable of taking care of the work, the shops have been provided with money and orders for getting tools and increasing their capacity, and so have been able to go on with the work. We need various other things besides tools. We need men of imagination. Engineers are, in general, people of imagination. We need men who can see the possibilities for making things they have never made before. A great supply of trained workers are needed. The Shipping Board is training a large number of men for sea service. It now has a program, including the training of upwards of 100,000 people at different points in this country—some 5000 or 6000 of engine-room officers and a similar number of deck officers, stewards, cooks, and all people that go on board a boat are being trained under the recruiting service of the Shipping Board.

We have here in the city of Philadelphia a very large marine engineering school meeting nightly at the Bourse, and there is a navigation school at the University of Pennsylvania, classes meeting every day and every evening.

The training ship, *Calvin Austin,* is taking out crews every week from the city, giving them a certain amount of training. That is being done—but people must also be trained for the shipyard at Hog Island. There is now a school at the Island in which crews of men are being trained to handle individual parts of the installation work on the ships.

There are two template ships, or spaces. They are large buildings in which one initial set of machinery for each type of vessel is being erected. It has been expedited ahead of the rest of the machinery and is being put together there by the men who will do the erecting aboard ships. The purpose is not only to train the men to go at the work expeditiously, but to check up the material as it comes in to see that it will go together and to make templates for piping and other parts. When you are ordering material for 70 ships or 110 ships, you must be pretty nearly sure that it is right, as you order it, and that is the purpose of the template work.

It is very important to be sure of getting enough material. It is not sufficient to know that you can get part of it, but you have to get it all, and then double and treble what we think is needed at the present time. So there is a real problem before all the engineers in this country, in developing the resources of our shops so that they can do things which they have never done before, but which they have demonstrated within the past six months they are able to do. From the response that has been made from those who have gone into the work already the engineers of the country are enthusiastically behind the shipbuilding program. Those who are criticising it are very largely the men at a distance who do not know what is being done. It has often been said "the man we don't like is the man we don't know." As more of the industries turn their attention to the present need for marine machinery, an increasing interest and loyalty will result, and will enable us to build up a tremendous merchant marine. This is certainly of first importance at the present time.

ADDRESS*

By DR. LYMAN ABBOTT

WE talk of a war in Europe. If we used language with accuracy we should not talk of a war in Europe. There is no war in Europe. There is a *posse comitatus* summoned from the various civilized nations of the world to protect the peaceable nations of Europe from the worst and most efficient brigandry the civilized world has ever seen.

This is not rhetoric; it is a calm, simple, accurate, scientific statement of facts.

The classical definition of war is furnished by Charles Sumner in an address on the "Grandeur of Nations," delivered in Boston in 1845, based on authorities then and there by him cited, and accepted ever since as an authoritative definition. It is substantially in these words: "War is a conflict between the armed forces of nations under international law to determine a question of justice between them."

There are two things necessary to make a conflict war. It must be to determine a question of justice, and it must be under international law. There is no question of justice at issue in Europe to-day. When this war was begun in Germany her prime minister said to the Reichstag: "We are going to do an act of injustice to Belgium; we shall try to repair it afterwards."

In 1913, the year before that declaration, Bernhardi, one of the leaders of the military party in Germany, had said: "War is a biological, a moral and a Christian necessity." He had said: "We are going into this war, among other things, so to crush France that she can never cross our path again."

Four weeks ago, a paper appeared before the public issued from the pen of a German prince, who, in 1914, was the German ambassador to England. In that paper he declares explicitly that Germany egged Austria on to make war against Servia, that Germany refused the urgent entreaties of Italy, France, England and Russia to attempt a peaceable settlement of the controversy. And he unmistakably declares that Germany is guilty of having brought this war upon Europe and with that paper was published another by an ex-director of Krupp's, carrying home to the Kaiser, the emperor of Germany, that guilt.

In 1900, the Kaiser, in the dedication of a monument, declared that his ambition was to re-establish a Roman Empire, giving to Germany the same domination of the world that the Roman Empire had in the first century.

In the face of these facts, it is impossible to say that there is any question of justice to be determined in this war. I must call it war, because there is no other short word to use.

Nor is this war conducted under the sanction of international law. Germany has openly, flagrantly, avowedly, and with frankness, let us give her credit for that virtue,—she has openly and avowedly declared that she does not recognize the laws of nations, that she does not recognize the laws of war, that she does not recognize the laws of humanity, that she does not recognize the laws of God.

"Thou shalt not steal." She has robbed France and Belgium of their iron and their coal; she has robbed their banks of their money; she has robbed their churches of their treasures; she has robbed the homes of their pictures and their statuary and their furniture, and what she could not carry away, she has, in her wantonness, destroyed.

"Thou shalt not kill." She has not only killed soldiers in open warfare—she has murdered men, women and children, not a few, but by the score, by the hundreds, by the thousands.

"Thou shalt not commit adultery." Her soldiers, with the apparent sanction of the government, certainly with no opposition from the government, have raped more women than has ever been known before in the history of warfare.

I could not believe these things to be true. I thought them, at first, the exaggerations of newspaper reporters. Then, I thought them to be the extravagant outbursts of individual soldiers in violation of law. But I have compared more or less carefully the commissions issued first by Belgium, then by France, then by England, in which these outrages have been investigated, with names, dates and places given in detail with affidavits to substantiate the charges.

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* Delivered at National Convention of League to Enforce Peace, May 16, 1918, Philadelphia.

Germany has been asked by Great Britain to unite with her in an investigation, and Germany, by refusing to share in such an investigation, has pled guilty to the charge. But that is not all. In our Civil War, Mr. Lincoln appointed a commission to prepare rules of warfare, and it is said that after the military officials had prepared them he, if I may use a somewhat barbaric phrase, "englished" them. Those rules of warfare prepared by our government under Lincoln's beneficent administration, became the basis of the rules of war accepted by the Hague Tribunal.

Compare these sets of rules of war, that of America, that of the Hague Tribunal and those established by the German war-book. According to the rules of civilized warfare, war is conducted against the army of the enemy. According to the German war-book, it is conducted against the people of the country. According to the rules of civilized warfare, churches, hospitals, libraries, public buildings, are as far as possible to be guarded from destruction. According to the German war-book, they are to be destroyed. According to the laws of civilized warfare, the property of non-combatants is to be generally regarded as sacred, unless great exigencies require destruction. According to the German war-book, the property of non-combatants is to be destroyed for the purpose of producing terror. According to the laws of civilized warfare, the captives taken in war may be used in peaceful industries, but not for maintaining the armies or manufacturing the munitions to be used against their own kinsfolk. According to the German war-book, they may be so used.

The laws of war and the laws of nations have been ruthlessly set aside. Nor is that all. The crimes that have been committed by these bands of brigands have been glorified. They have been proud of their booty. They have organized triumphant processions. They have struck off medals; they have sung hymns of praise; they have preached sermons in their pulpits and addresses on the platforms in praise of the men who have committed these unspeakable crimes.

I repeat—it is not rhetoric; it is simple, calm, historic, scientific statement of a fact that in Europe the Allies are fighting to protect lands of peace from brigandry. The question is, What is brigandry? The definition in the "Century Dictionary" has only five words. You can easily remember it. "Highway robbery by organized gangs." Was there ever highway robbery conducted on so enormous a scale by so ruthless and unscrupulous a gang as what Henry Van Dyke has well called "the predatory Potsdam gang."

I have been asked to speak to you on this theme, "Democracy or Autocracy—Which?" What do we mean by democracy? It is not a mere form of government. France is a republic and Italy is a monarchy, and Italy is as truly a democracy as France. America is a republic and England is a monarchy, and England, in some respects, is more democratic than the United States.

Democracy is not a political opinion. It is a religious faith; it is faith in our fellow-men; it is faith in one another; it is respect for each other's rights; it is regard for each other's opinion; it is human brotherhood, and its name or its motto might well be that which you have made the name of your city—democracy is the land of brotherly love.

Nor is autocracy a form of government. I will not go into the history of the past. Enough to say that autocracy as we face it to-day in Europe is organized brigandry which denies the elemental rights of humanity, the right to live, the right to liberty, the right to the pursuit of happiness.

Any man who proposes a compromise or a peace negotiation with this band of brigands is guilty of treason to the kingdom of liberty.

I am a Christian minister. I am glad here, and on all occasions, to acknowledge Jesus Christ as my Lord and Saviour and my Master. I take my commands from Him. I can honestly say that I have no desire so great as to have something of His spirit, no wish for my life so great as to be His follower. I naturally turn to the book in which His name is enshrined for my commission. I find it in the words of the oldest prophet of the Old Testament. "The serpent shall bruise man's heel; man's heel shall bruise the head of the serpent." The head of the serpent is upraised with wrath; its very breath is poison and we have, perhaps, a difficult task to get our heel on its head, but when we do, we will grind it to powder.

I turn the pages over to the New Testament, and I find there the commission of my Master interpreted to me in these words: "They that take the sword shall perish by the sword." Not by earthquake, not by peacefulness, not by thunderbolt, but shall perish by the sword in the hands of man. We have that sword given to us by our Master, and we will not sheathe it until the predatory Potsdam gang has perished from the face of the earth.

RECENT OBSERVATIONS IN FRANCE *

By DAVID S. LUDLUM

PRESIDENT AUTO CAR COMPANY

I WAS one of a small party to go to France and study the motor transport service of the army; that was our mission. It was not so much to study it over there as it was to get at first hand what they were doing over there and what you needed to do over here, to make it possible for them to carry out over there the plan that has been worked out. The motor transport service is a new department in the quartermaster's department. It has been authorized under General Order No. 38 by the General Staff. It is a long, long step in the right direction. The officers of the Army who had gone to France several months ago studied the motor transport necessity, analyzed what was going to be necessary, and worked out a most comprehensive plan and method of operation. Their plan has been endorsed by the General Staff in Washington in its entirety, and I think that is a big step in the right direction because it has all been done within the last few months.

That means that the motor transport service in connection with the United States Army in assisting to win this war is a very important army.

When you consider that it will be necessary to use between 50,000 and 60,000 trucks in France, for every million men we take over, it means that this is a big proposition. The motor transport service is based on good common-sense business principles. It means this, that hereafter all of the motor vehicles used by the Army for each department will be purchased by the motor transport service, and I think this Society has been very much honored by the appointment this last week of one of your fellow members—Colonel Frederick Glover, of Rockville, Ill., as chief of the motor transport service in the United States. He has a very important position to fill. That means that the service will purchase the cars, will inspect the cars at the factories, will operate the cars from the factories, if they go over the highways, to the seaboard, will crate the cars if they are going to be crated, disassembled, likewise the parts, and inspect them and follow them thru to the seaboard. They are turned over to the transports on the other side; they are met at their receiving ports at the docks by the motor transport service again, who take them right in the same department, unload them, reassemble them if they have been disassembled, and operate them again thruout France and wherever they go and also maintain them. It is one complete organization. That operation remains under the M. T. S. up to one last point. Those cars that go into a division as a division unit are turned over then to the commander of the division. It means that practically seventy-five per cent. of all the cars in France will continue to operate under the motor transport service and under one head.

When we went abroad we went into Bordeaux, and a few miles out of Bordeaux, along the River Gironde, we are building a dock that is about five miles in length which will be used by all the boats, or a large number of them will use that port to transport material to France. These docks are nearly completed. It was a great sight going up the River Gironde at about eleven o'clock in the morning. We had about two hundred marines on our boat, and one hundred and fifty American soldiers. We had about eight hundred Russian recruits. We had Red Cross workers, Young Men's Christian Association workers, Salvation Army workers, Young Women's Christian Association workers, newspaper correspondents, some American officers, some French officers who were on their way back after having been here in America after a leave of absence, and as we were going by these docks the marine band on our boat started to play "The Star Spangled Banner." The workmen all stopped; our soldiers, black and white, stopped to come down to the edge of the docks all the way along that five miles, and cheer after cheer went up. It was a great reception for all of us, because the trip across of twelve days was taken by us all alone, our boat did not have any convoy; we simply slipped out of New York and slipped into port, and it was really a very inspiring moment.

At Bordeaux, as at other ports, getting back to motor transportation, we arrived at what we call Reception Park. At Reception Park they have a repair department so that if anything comes over there smashed or broken it may be repaired and they have trained drivers where they start the trucks across the country. When I say across the country, practically most of you have looked at the dotted line of the battle front, and we have from three hundred and fifty miles to five hundred miles to cross, depending upon what fort we take our supplies to, to transport a very large portion of everything that we are going to take to the boys to the front. I am making that statement. It is not intended in any way to depreciate what the railroad engineers are doing. They are doing wonderful work, but we have to transmit a tremendous amount of material to that front, and we must do it over the highways, and, speaking of highways, they have them there. In France are the greatest roads that

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* Delivered at the Annual Dinner of the Pennsylvania Section, Society of Automotive Engineers, May 25, 1918, Hotel Adelphia, Philadelphia.

I have ever seen. If they did not have them it would be a very serious situation—this war—and we would be in a very serious position and be of very little help for a long while to come; but fortunately they have them, and I hope that some day we will have them here or something similar to them. The motor transports are directed from this one head at a general headquarters in a certain city in France, very properly picked out. They are directed to their respective designations, no matter where that may be, and that direction must go from the central point. In the central part of France there was being erected and is now probably finished, the largest service station and supply depot that the world has ever seen—entirely for motor trucks. It is capable of expansion for every department without any reconstruction. That plan was all worked out here in Washington by the men whose duty it was to undertake it, and the three thousand men—the first units to take charge, together with their machinery and the material for their buildings, together with every conceivable thing necessary for the establishment of that plant—arrived in France practically at the same time. Thru that plant everything will radiate; all parts will be supplied from there to the front. In that plant all cars, no matter what make, will be overhauled—not the car itself but the units thereof, and from there they will go out to various other repair stations, and from there go to the mobile station, so that under the plan which is now functioning we are going to have the best automobile motor service of any army in the world.

The question has just been asked me whether these five miles of docks are being built by American engineers. I want to say, yes. I want to say to you that I saw the engineers there widening the railroad tracks, building bridges, mending the roads, mending shell holes; I saw them mend a shell hole and we were over it an hour after it had been blown up and it was all mended. The engineers and the signal corps were working right together. I saw them putting up telegraph poles and wires which had been knocked down not an hour before, and the engineers are doing wonderful work. I do not know whether they have only one army in the United States, but I know we have one army over there, and each department is up to the other fellow. It is unification right straight thru.

I was in an automobile repair station. One of the engineers came in to get a job done. Incidentally I had a tooth filled in the same repair station, because I broke it off. I mean that. I turned to the colonel in charge and I said, "I broke a filling out of one of my teeth." He said, "Wait a minute." He telephoned for a man to fill it. He had a dentist there.

I speak of that repair station just to give you a simple idea of what is being done. The stock room and store room for parts and units is laid out for 300,000 square feet on one floor. I am a little bit familiar with distances in the city of New York. It is the space between 23rd and 24th Streets and 8th Avenue and 11th Avenue inclusive in New York. I am inclined to think that they will have to have roller skates and bicycles probably to get around it. But there is no need of doing it half-way, and we are not going to do it half-way so far as the motor transportation is concerned. It is a great big job they have on their hands and they are going to do it in a great big way. While I am speaking of that great big job, I want to say *we* have a great big job. Mr. Musselman asked me what I wanted to talk about, and I told him that I did not know that I wanted to talk at all. "Well," he said, "your observations." There is one observation I came back with, and that is that we have a great big job on our hands. I can state absolutely that I know just when this war is going to stop—and it is not going to stop until then—and that is when Germany is licked. And Germany is not licked yet. She has given no evidence of it. And we do not want to make believe that she is licked, and I think the biggest message I can pass out to you to-night is that we want to go at this war in a great big way. My idea of a big way may be different from some. Some think the big way is to drop all their business and everything else as a non-essential. I do not think so. I do not think that is the big way. That is the big way to let Germany get a victory over the United States. Germany would be very glad if she could make us poor, but she cannot make us poor. We will not let her make us poor. But we ought to plan this war for four years' duration from to-day, and then, as each month or each three months go by, or each six months, if the war is not over, plan that as six months we have consumed on the other preparation, and keep prepared all the time for four years ahead. Figure out approximately how many men we can use and how many pairs of shoes we can use and how much clothing, how many guns and ships we want during the next four years. If we guess wrong fifty per cent., all right; if we have guessed right fifty per cent., prepare for it and go at it and we will win this war without a great big sacrifice of our business industries in this country, or a big sacrifice of men.

When I arrived home from France I happened to go into a hotel, the 30th day of April, for lunch. A man was making a speech for the Liberty Loan, and he said, "We are going to be in Berlin in ninety days." I could not help asking him the question why he wanted to sell a Liberty Bond if we are going to be in Berlin in ninety days, because if we were there would not be any need of selling any more. We would not need anything more to go over there, we would have enough over there, because it would be humanly impossible for us to get into Berlin in ninety days, or even a good deal longer time.

Another thing that struck me when I got home, and that was people said, "Why, you have had an awful drive there, and we have felt the effects of it here. It has upset business." Gentlemen, there are going to be more German drives, probably some bigger than the last. There are going to be more Liberty Loan drives. We have simply got to learn how to go on and do business and handle our business and equip our men and get out what is necessary for this war without becoming hysterical about it or upset about it. If we do, Germany is going to win a victory over the United States, altho she will not win the war. We must keep our wheels of industry going around, and if I can pass that message along to anybody at all that can use any influence to get their concern to look ahead—the men in charge of their plant to look ahead for four years all the time, I hope I have done some little good. I am going to look four years ahead so far as our concern is concerned. I am going to do something else that we have been probably careless about, because I feel if that is done by everybody we will not lose any man power in this country, even tho we put five or six million men in France, which I believe we will have to do before we win or help to win this war. We make a great mistake in saying that *we* will win the war. France, England and Italy have done great work, and the best that we can do is to *help* them to win it. We had enough inefficiency and idleness in this country prior to our entering the war to take the place of every man that is going to be necessary to send over and to supply him with everything he is going to need, if we will just take up the slack that we had prior to the war. What we want is increased efficiency out of everything, and we are going to get it, and the boys over there deserve it.

You would feel very proud if you could see the boys in the various cities in France the way it was my pleasure to see them. We visited a large section of France. The cheerfulness and the determination on their faces showed the lives they are leading. Our boys in France, gentlemen, are leading clean lives. You see that in the small town, you see it in the large city. Our military police in Paris and other cities—and they have a splendid police force—it is a great sight to see them in the various towns and cities.

Now a word about the spirit of the boys. We were wandering around the various cities at night, and in civilian clothes you can learn a great deal more than with a uniform on. I told the colonel one night that he ought to borrow my clothes and fuss around at night with the privates and he would get some information. One night we went out to take a walk and we met a young fellow, and he tried to ask us a question in French. We said in English, "What do you want?" He said, "My God! are you Yankees?" We said, "Yes." He said, "Come here, fellows," and in about two minutes we had twenty-five around us, and they were all very cheerful. They were a fine lot of fellows. One of them wanted to know if I knew where Camden was. Another if I knew anything about Hoboken, and another fellow spoke of Cincinnati, and we had a nice real party with them. They were a fine bunch of boys. It happened to be the Eleventh Engineers, and I guess some of you fellows know the Eleventh Engineers had a pretty tough time of it, and the stories they told confirmed some of the stories I had read. This was the 27th of March. I said to one of the boys, "Where are you going?" He said, "Going back to the front." "Well," I said, "where have you been?" "I had a furlough. Had a big time, too." "Is that so?" I said: "Tell me about it." "Well," he said, "I will tell you; I saved up my furlough. I came over last July because I wanted a real party and I had nine days coming to me, and," he said, "I went down with a couple of friends to a city resort which had been taken over by the United States Government and it is used as a resting place for our American boys, and they tell me it is everything that anybody could ask, and I think it is a great work there." I said, "How do you like it there?" He said, "Fine. You go down there and put your hand in a box and pull out a ticket and get your room. My friend and I got a peach of a room—a big double room and a bath." He said, 'You know about a bath in France, don't you?' 'I have not had any; let me go with you,' he said. Well, we went down to dinner and were served by waiters with dress coats on. We had a big dinner and went to bed in a real bed with springs in it and we did not have to get up early the next morning. We got up and had such a good bath and shave the night before that we took another bath and shave, and we went downstairs and had coffee and rolls, and my friend said to me, 'We are not here. We are not alive. We have got rid of all those things creeping on us,' and he said, 'This is not real at all.' I said, 'Yes, it is. I can feel myself and know I am here." Just then a courier came along and asked, "Are you boys of the Eleventh Engineers?" "Yes," he said. "Well," he said, "you must report back to the front at once." That was just one night. Yet they were going back cheerful and happy to do their part.

We are going to win this war, and do not let us be impatient. If we only can be patient and take our time and hold the Germans they may make some drives and come in and be shoved back with great slaughter. In that last slaughter, the best figures we had before we left France, from American officers, was that the Germans lost eight to one. If they want to do that they can go on. We will take our time until Germany is licked. It may take years. It may take a long while.

We have to use at least three to four men behind every man at the front in France, so that when you have four million men over there you have only one million at the front. We will take our time to get them over. I believe with the coördination of the armies as now laid out and the general plan that was talked about by those in authority that if the United States will not become impatient and send them over equipment and everything else, that they will bring back ninety per cent. of all the men we ever send over. But if we do it the other way, and put up a cry, "Pershing, go do something!" we will slaughter half of them. I have a message from the front. Just as I was going away in a hurry—the message came for me to go on Saturday, and we left on a Tuesday. My little boy said to me as I was taking him to school the morning I left, "Daddy, here is a little note for you."

He handed me a little piece of paper and said, "Will you deliver that for me?" I said, "Yes, son, I will." It was a note to General Pershing, and so I folded it up and put it in my pocket. Unfortunately when at headquarters General Pershing was at the British front. However, the next time we were there he was away then, and I went to his colonel, and I said, "Colonel, I have a message for General Pershing that I do not dare go home without delivering. It is a real message. It is a real thing that he wants to be done by General Pershing, and I believe if the General got the message he would pay attention to it." The message was as follows:

ROSEMONT, Pa.

General Pershing:

When you catch the Kaiser, biff him one for me.

(Signed) STEWART D. LUDLUM.

When I got home Stewart, after a little while, said to me, "Did you see General Pershing?" I said, "No; I am sorry I did not see him; but I did the best I could. I went to Colonel Collins, his chief assistant, and I explained your note and he said he would give it to General Pershing." I saw the boy's jaw go down. I was very much pleased, however, when I got down to Washington the other night to receive the following message:

AMERICAN EXPEDITIONARY FORCE.

MASTER STEWART LUDLUM:

My dear Master Stewart,

Your father handed to me a message for General Pershing which I have since shown to the General, and he has requested me to say that it is only a question of time when your suggestion regarding the Kaiser will be adopted.

Yours truly,

(Signed) COLONEL COLLINS.

IMPRESSIONS OF THE GREAT WAR*

By HARRY L. HORNING

VICE PRESIDENT, WAUKESHA MOTOR COMPANY, WAUKESHA, WIS.

THE trouble in America, I feel, day in and day out in the work I have done, is that we have not come in contact with the real current of the war, and such visits and travels as Mr. Ludlum has made have got to become more frequent before we can feel the influence of the things going on over there, and for the benefit of the war and for the benefit of our country we must get busy and go over there, each and every one of us, and see with our own eyes and feel and realize the distress and the sacrifice that some men are willing to make and then contrast it with the selfishness that some men are enjoying in America. This leads me up to the two things I wanted to say, and they are in regard to the Liberty airplane engine and the Liberty truck. You have read so much in the papers about the failure of the airplane program that I am forced by the circumstances of the last month and the things that I have seen to remain silent no longer. I had the great privilege, with Mr. Bachman, of visiting a factory in Dayton, Ohio, and I had the great pleasure of seeing a De Raviland, D. H. 4—our combat plane—at the flying field. Beside it was another plane with the finest engine that is built abroad, the Ross. It warmed up for about eight or ten minutes, and we all anxiously awaited its leaving the ground. The aviator adjusted his cap. Everything was in fine fettle, the motor hitting on all cylinders, and I tried to stand behind it, and when it got away all I had was a suit of underwear, and it got about half a mile away. Beside it was throbbing our own Liberty motor, in a plane identical in every respect, and there for the first time in America, in a country that did not believe in its own great geniuses that have foreseen the airplane necessity, we saw the Liberty engine leaving the ground, and after the Ross-equipped plane had gotten a half mile start on it, it was only seven minutes and ten seconds before they caught it at 10,000 feet. They talk about thirteen and fourteen minutes abroad. We went into factories and saw planes upon planes, and I am notified that the production last week was far beyond that which any one could expect in that factory. We had the great privilege of going thru a department there which is very seldom allowed to the public, and I had the great privilege as an engineer of entering a room which I supposed by the talk going around would be shut to me, and that was the repair room for the Liberty engine, and yet it was open. I want to say to you as an engineer that in that room there resided the greatest hope of America—that was that the things they were repairing were so modest—things so ordinary that I have the greatest hope and the greatest confidence that we have the best engine in the world. I went thruout this airplane factory. I noted the way they were manufacturing. I remember that Mr. Clarkson coming from England telling me that in the most important factory in England manufacturing the best engine they produced they are manufacturing only twenty-five planes a week, whereas the Packard factory has far exceeded that number in one day. I am told that it takes 150 working hours to make one Rodroyce cylinder. It takes one-fifteenth of that time to make a Liberty engine cylinder.

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* Delivered at the Annual Dinner of the Pennsylvania Section, Society of Automotive Engineers, May 25, 1918, Hotel Adelphia, Philadelphia.

In those eventful days of a year ago when the engineers gathered to design this motor I had the wonderful privilege of walking in and out of that room during those three days of designing, and I remember how, afterwards, we got together and kidded ourselves as engineers that possibly when the twelve-cylinder engine was made it would deliver 375 horse-power, but it has exceeded the performance of any engine in the world. Since then I have heard from time to time how it had reached 375 H.P., 390 H.P., how it had reached 400 H.P., 420 H.P., and I have even heard of it going to 450 H.P., and if the knowledge that I have of thermo-dynamics is true, and the things that are going on in Washington are true, and the things that have developed in Dayton are true, there is a good chance for the American engine to go to 500 H.P. We have had trouble. We have had to change things, and who has not? But the most marvelous thing in all this work, a thing that the engineer will appreciate, was that the exhaust valve is giving very little if any trouble, whereas some of the fine engines that are being built to-day of the foreign make will go to pieces in eight hours when run at sea level with high compression pistons. The Liberty engine goes for days. It takes one-tenth the number of hours to produce the Liberty engine that it takes to produce a similar engine abroad by the other methods, and I am told that within three months or until about the first of September we will only be about 200 engines behind the schedule.

I am very glad to testify to you gentlemen that my section passes on the purchase of Liberty engines by the Allies. Whenever an Ally wants to buy a Liberty engine the request comes thru our section, and we see it first and we call up and see if it interferes with any of our own program. We try to develop additional sources for Liberty engines, and I want to record here without disclosing any military secrets that there are literally thousands of Liberty engines desired by the Allies who know thru the years of experience what an engine should be. I am very glad to state to you that one of the disturbing factors who have tried to down the effort of America to produce an American product in American factories in an American way, trying to introduce another engine instead of a Liberty, have had that very engine dumped in England, and that very factory is producing another make of engine to-day. It was thru their pernicious influences that they were trying and have tried for over a year to disturb the peaceful way of the Liberty engine, and yet to-day their own factory in England is producing another engine. I could go on in a great many other ways and show you the things we have seen with our eyes, and I wish *you* could see so that you can act as messengers of the truth to the people of the United States who should know it when they are asked to give up their good money for all this, because they are willingly giving it up and they are not being told the truth. Let us hope that it will come out at the meeting of the S. A. E. after the official test which will be made about the first of June—that the results will be read at the June meeting, and we hope that if there is no other body in the world that can tell the truth we will give it at that time.

Leaving the Liberty engine and leaving the other question of the airplane, I want to say a few remarks about the truck. You no doubt have heard and read many contradictory statements. On the first day of August we arrived with 50 engineers in Washington, and during the whole month of August, which started with a temperature of about 110 degrees in the shade, and ended up I do not know where—we worked and scrapped and fought as doctors and engineers will trying to decide who was right, and the month went by. It seemed to me to be a long month; I have often said that we worked forty-five days in that month. On the first of September we finally got down to business, a schedule was made, and this is what we had to do. They said on the 10th of September the drawings would have to be done on this truck, and on the 30th of September the parts would have to be done, and on the 10th of October the truck would have to be running, and on the first of January that truck would have to be in production. The facts are that on the 10th of September the trucks were far enough along so that we could proceed, and on the 28th of September the first engines running and on the 10th of October they started for Washington, two of them—one from Ohio, the other from New York. On the 14th of October one of them was driven into Washington. That was the record of producing that truck. I do not know of any parts being taken out, and they are still going.

I was notified last night that this month so far there have been 1800 trucks produced, and altogether at the end of the month there will be somewhere in the neighborhood of 3000 trucks which will have been produced, and next month the rate will probably be 2300 to 2400 trucks; and without disclosing any military secret I desire to say that it is faster than they are being shipped abroad. In the last week there has been a secret military test, and it is not for me to tell you all the results of all the trucks that have been built as standard trucks, but I can assure you that it should be the pride of all the members of the Society of Automotive Engineers, that we have under production the greatest aeronautic motor in the world to-day and the most efficient trucks that have been produced for this war.

SOME FUNDAMENTALS OF AVIATION*

By **WILLIAM B. STOUT**

MEMBER OF AIRCRAFT BOARD

THE matter of aviation—flying machines—has a rather definite distinction in comparison with the other lines of effort that we are at present engaged in against the Hun. At Hog Island there is organized, large-scale work on the shipbuilding program. In planning and putting into effect this program the men in charge are men experienced in the industry. They know how the routine of ship design can be organized and carried thru. They know how the material for the plates should be made, both as to chemical structure and as to treatment; they know how the rivets should be spaced, and how they should be applied, and what kind of machinery is necessary for putting them in, and all the allied industries that relate to every detail of the ship's production. They know also how to build ways for launches, and how to build all accessible machinery.

I might say the same in regard to the truck. When the truck was built we had a great many engineers in this country who knew of automobile design requirements and materials and organizations which fitted that type of production.

When we started on aircraft, however, we had no engineers in this country of sufficient experience to attack the gigantic problem of aircraft production and design, so that in the aircraft program we had to start from the ground up; we had to learn what a machine was, what it was for, how it could be designed and what could be done with it. Our knowledge in this country as expressed by the planes we were producing, was very limited. To go into the aeroplane business before the war on account of patent rights in the situation was to buy a lawsuit, and ordinarily men of real business ability had not gone into the aeroplane industry because they could see under the patent situation no possibility of profit. So that in starting the program we had in some ways more of a problem than almost any other branch. There was one satisfaction in it—that the other countries were not very much further ahead. They were ahead by the measure of time they had spent in the war. They were ahead on design. They were not so far ahead on production, and in this country with its production methods we have the possibility of doing greater things in the quantity line than can be done by the hand-fitting methods of Europe.

I was talking with Henry Leland the other day, formerly of the Cadillac plant and now of the Lincoln Motors Company, producing only Liberty engines, and he was telling of a talk he gave in the East to some manufacturers' association, and he said, " While I was telling them these facts about aeroplane and aircraft some fellow in the back of the house got up and said, ' If all these things are so, how about the failure of the aircraft program? ' " Those of you who know Mr. Leland may appreciate the answer. He said, " That kind of made me mad at that fellow for a few minutes," and he said, " I told him a few things."

Mr. Leland is between 75 and 80 years of age—and he is a man who, as everyone has said, has been thru it several times—and he always comes back. A rubber ball is never old as long as it bounces back, they say. He said, " When this man asked this question about the aircraft program I lost my temper. I said, ' Look here, sir; suppose I were a gentleman farmer, and there is a gentleman who lives in the city and lets some fellow run his farm—and I should come out to you some day and call you in and give you 40 bushels of seed corn and I sent you out on the farm and I would say, ' Now plant this seed; I want to raise corn this year.' And then suppose I would come out in my automobile two weeks later and I looked over this farm and I said to you, ' Where is all this corn I told you to raise? ' "

Now, anything to the contrary, there are some things being done in the aircraft program. We have heard of the Liberty engine. I do not want the impression left, however, that we are not going to have any trouble with the Liberty engine. If you know of any machine that we never have any trouble with, I would like to know about it. No machine is 100 per cent. perfect. Even Ivory Soap doesn't claim it—and it is not a machine. But the fundamentals in the Liberty engine are ahead of any aircraft engine which has been built and is in production to-day; there is no question about it. A certain British flier came over here a few months ago—one of their prominent fliers—who was very much married to a certain make of motor which he had been flying a great deal; he made a speech the other night before a crowd of Englishmen and Canadians in a certain American city; he was not talking to a crowd of Americans aiming for effect, but he was talking to his own people about things he knew from a number of years of experience and flying at the front almost since the war began. He said, " I have driven every aircraft motor which has been used on the front to-day; I have used them all. I know what they will do and what they will not do," and he said, " with all this criticism of the Liberty engine to-day I want to say that I have never been up behind an engine, foreign or American, French or Italian or English, that will compare with the Liberty engine."

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* Delivered at the Annual Dinner of the Pennsylvania Section, Society of Automotive Engineers, May 25, 1918, Hotel Adelphia, Philadelphia.

Now, do not get the wrong impression by that. Suppose we were to start in as very learned men with all kinds of reputation and investigate the shipbuilding work and we should go to the designers of the ships and looking very wise should inquire about the engines and we should say to the men we were investigating, "I understand that this 5000 H.P. engine here for your Atlantic freighters drives those boats at a certain speed." "Yes, that's the thing." "Now, I understand that a little engine of a few hundred horsepower in these destroyers drives them at twice the speed." "Yes, that is so." "Well, isn't that enough? Your engine is a failure; the small engine is driving the boat faster than your big one can." There is just about as much sense in that as to compare engines in aeroplanes. The results you get from an engine depend very largely into what the engine is put. If you want to build a freighter, you do not build speed lines on it. If you want to obtain great speed you do not merely crowd horsepower into anything that will float. You can put any amount of horsepower in a canal boat, but you cannot make a speed boat out of it; it will only pile up a wave in front of it. On the other hand, you cannot use a speed boat for large carrying capacity by any method we know. The same is perfectly true with aeroplanes. We have to-day in use planes weighing about 400 pounds complete with engine, which will climb approximately 10,000 feet in 10 minutes, with one man and fuel, flying 100 and some miles an hour, equipped with an engine of about 40 H.P. We have also aeroplanes in use weighing 20 tons, with something over 3000 H.P. in engines. You may take your pick between these extremes; and so it is with ships; you can design your ships between, and you must.

Performance in an aeroplane is not dependent upon the power of the engine but on what you put it in—by the plane. If you want speed you must have what we call a speed wing curve, and a speed wing curve will permit you to travel rapidly, but it will not lift as much per foot of surface as a lifting curve The lifting curve has quite a steep angle to it so that it will strike the air at a steep angle; but if you try to crowd such a plane to high speed, as your speed increases the pressure against it greatly increases, and you have a pressure on the nose which builds up a bow wave. We found this to be true by a test. For instance, we took one of these planes that were formerly fitted with a 200 H.P. engine of a certain make. We put a Liberty engine in it of practically double the horsepower with almost the same weight. The public would immediately damn the Liberty motor because the plane was only about seven or eight miles an hour faster. Suppose you should take a canal boat puffing along at five miles an hour and double the horsepower of the engine, I doubt if you would get six miles an hour. And so, if you take a slow type plane you are going to get slow results, because it is not built at the flat angles which are required for high speed.

It does not matter what the horsepower of your plane is, or your engine, you can get the same results with 40 H.P. that you can get with 4000 H.P., except for useful load; you can get the same speed and the same climb, but you cannot carry the same load. You cannot transmit that power with as great a range. You can take a motor car and put on a gear ratio and accelerate at slow speed for hill climbing to a tremendous high speed for a level smooth road, and use your gears for low speed. The same is true of the aeroplane. The new problems that come up that are going to disappoint us for a while as regards the plane are the things that always disappoint us in a car. We are going to have comparatively little trouble with the Liberty engine, and when you remember what tremendous service facilities we can obtain because of the interchangeability of parts which no other engine has, we will have less trouble with the Liberty than with any other type of engine. We will have practically no trouble with the planes; and you will remember that in your motor cars you have practically no trouble with your engines now, and you have practically no trouble with the car; you have most of your trouble with the connection between the two—your wiring, your piping, your coupling of the engine to the frame. Everything down the line between the engine and the car is what gives you the most trouble.

We are getting—I might say—into a period of development of the connecting details, if you can call it that. We have just gone thru that. You have heard that the Liberty engine overheats, perhaps. If you put a radiator on a car that is only half big enough or that has the water passages stopped up and one thing and another is the matter any engine will overheat, if you do not give it the right radiator. When we started in we had absolutely no experience on the air operation end, and we could not expect our radiator to be just right—to hit it right the very first time—and we did not. But cooling is not any problem with the Liberty engine; it was a problem of getting the proper radiator, and it was cured within a few weeks after the motor first went into the air. We have now enough data so that the next time we will know what to do. We can design a ship now and put a radiator on it and know what it will do, because we know how many square feet of radiating surface we have to have per horsepower.

Remember that there is one very great difference between aircraft and any other kind of vehicle, especially as related to the engine—that in aircraft you are changing temperatures and air pressure all the time, and within a few minutes. In modern war conditions you may be surrounded by an atmosphere having a temperature of 100 degrees in the shade, on the ground, one minute, and twenty-five or thirty minutes later you may be in an atmosphere having a temperature of 10 or 15 degrees below zero, at a high altitude, and with an atmospheric pressure of only a small percentage of what you have on the ground. Aeroplanes are climbing now

(Continued on Page 345)

PLANT EXTENSIONS OF PUBLIC UTILITIES FINANCIALLY CONSIDERED

By JOHN W. LEDOUX, Member

AT the New Orleans meeting of the American Water Works Association in 1910, the writer presented a short paper calling attention, among other things, to the danger of making water-works extensions without adequate returns.

Since that time there is good reason to believe that this subject has been receiving careful attention by many water-works engineers and superintendents.

In past years it was common practice for the water-works management to install at its own expense an extension where the revenue in sight did not exceed 10 per cent. of the cost of said extension.

It is the opinion of the writer that under ordinary circumstances it does not pay to lay a water-works distributing pipe extension unless the annual revenue obtainable thereon is considerably over 25 per cent. of the cost.

An examination of the statistics of privately owned United States water-works plants shows that the distribution piping system upon which consumers are located will cost from 25 to 65 per cent. of the cost of the entire works; 45 per cent. representing probably a fair average. They show also that the entire cost of operation, not including depreciation, will generally range between 3 per cent. and 7½ per cent. of the cost, a fair average being about 4½ per cent. This cost of operation will also be seen to range between 25 per cent. and 75 per cent. of the gross revenue, a fair average being about 45 per cent.

In these respects every water-works has its own particular characteristics. For many gravity plants as well as advantageously located pumping plants, the operating expenses, when considered as a percentage of the cost of the plant or of the gross revenue, are comparatively low.

The relative cost of the distribution system will depend largely on the number of consumers per mile of distribution pipe and the adequacy of the fire protection.

If a demand were made upon the water-works management to lay a pipe extension at a given location, the first consideration would be whether the pipe would be used for domestic and industrial use, fire service or both. If the former, a large quantity of water will be consumed. If for fire service scarcely any water will be consumed, so that at first sight it would seem that much less percentage of return on the cost of the extension will be required if the service is to be entirely for fire protection than if for water consumption, for the latter taxes the entire plant, while the former generally taxes only the distributing system. However, it is believed that it is not necessary to make any such distinction, except in special or unusual cases. Reasons for not making distinction between the two classes of service are becoming more apparent when it is considered that the modern tendency is to make the principal charge for fire protection an annual payment of a fixed sum per foot or mile of distributing pipe.

Let us assume that for a particular water-works system the cost is $1,000,000, the cost of the distributing system is 45 per cent., or $450,000, the gross revenue is $135,000, and the operating expenses $45,000. Let us assume a fair allowance for depreciation will be 1 per cent., or $10,000. The net revenue will then be $135,000 — ($45,000 + $10,000) = $80,000, which is 8 per cent. of the cost of the works.

Now let us assume a demand is made for a pipe extension, on which there can be counted with reasonable certainty a revenue of $135 per annum. A reliable estimate shows the cost of the extension will be $450. The revenue attainable will be from average consumers as well as the regular proportion for fire protection. Under these circumstances we can calculate the rate of return as follows: If the distributing system costs 45 per cent. of the entire cost of the system, there must be added to the balance of the system, either before, at the time or after the installation of this extension $550 worth of non-revenue-producing plant, if we wish to maintain the entire works in its standard condition. According to logical accounting methods the revenue-producing part of the plant must earn sufficient to pay the required rate of return on both it and the necessary non-revenue-producing part of the plant.

In other words, every time a distributing pipe extension is laid there must be furnished an adequate portion of a new reservoir, filter plant, pumping engine, boiler plant, building, force main, etc.; and there must be sufficient return to pay for all these things; otherwise when required there is no financial means of obtaining them.

Every factory manager who has given the subject of scientific cost-keeping any consideration knows that this principle is fundamental: the producing part of the organization must earn sufficient to pay all charges, including the upkeep of the non-producing part of the organization. All this is usually lumped under the title of "overhead" charges.

We therefore have cost of extension..................	$450.00
Cost chargeable to balance of plant	550.00
Total cost	$1,000.00
Operating expense 4½ per cent.	45.00
Depreciation 1 per cent.	10.00
Return 8 per cent. on cost	80.00
Gross revenue required to maintain 8 per cent. return...	$135.00

The extension itself will then have to pay—

$$\frac{135}{450} \times 100 = 30 \text{ per cent.}$$

A simple formula universally applicable is

$$X = \frac{(O + R + D)}{P}\ 100 \quad \text{(A)}$$

in which

O = per cent. operating expenses is of total cost.
R = per cent. rate of return is of total cost.
D = per cent. depreciation is assumed to be of total cost.
P = per cent. distributing pipe system is of total cost.
X = per cent. guaranteed or estimated revenue on the extension is of estimated cost of the extension alone.

Another formula of somewhat more general application is as follows:

$$X = 10{,}000\ \frac{R + D}{P\,(100 - M)} \quad \text{(B)}$$

in which all the terms have the same designation as before, and M = per cent. operating expenses is of gross revenue. Tables A and B are calculated from formulas A and B, assuming the rate of return is 7 per cent. and the depreciation 1 per cent. on the total cost.

TABLE A.

Per Cent. Distributing System Costs of Total Cost.

O	P								
Per Cent. Operating Expenses are of Total Cost of Water-Works	25	30	35	40	45	50	55	60	65
	Per cent. of return required on cost of extension alone assuming 7 per cent. return and 1 per cent. depreciation								
3.0	44	37	32	27	24	22	20	18	17
3.5	46	38	33	29	25	23	21	19	18
4.0	48	40	34	30	27	24	22	20	18
4.5	50	42	36	31	28	25	23	21	19
5.0	62	43	37	32	29	26	24	22	20
5.5	54	45	39	34	30	27	25	23	21
6.0	56	47	40	35	31	28	25	23	22
6.5	58	48	41	36	32	29	26	24	22
7.0	60	50	43	37	33	30	27	25	23
7.5	62	52	44	39	34	31	28	26	24

TABLE B.

Per Cent. Distributing System Costs of Total Cost.

M	P								
Per Cent. Operating Expenses are of Gross Revenue	25	30	35	40	45	50	55	60	65
	Per cent. of return required on cost of extension alone assuming 7 per cent. return and 1 per cent. depreciation								
25	43	36	31	27	24	21	19	18	16
30	46	38	33	29	25	23	21	19	18
35	49	41	35	31	27	25	22	21	19
40	53	44	38	33	30	27	24	22	21
45	58	48	42	36	32	29	26	24	22
50	64	53	46	40	36	32	29	27	25
55	71	59	51	44	40	36	32	30	27
60	80	67	57	50	45	40	36	33	31
65	92	76	65	57	51	46	41	38	35
70	107	89	76	67	59	53	48	44	41
75	128	107	92	80	71	64	58	53	49

It is evident this method can be used for gas and electric light and power plants, and, in fact, the principle applies to operation of many kinds. Obviously for the term "cost" the appraised "valuation" can readily be substituted.

According to this discussion as the Operating Expenses are likely to be between 35 per cent. and 55 per cent. of the gross revenue, and the cost of the extensions is likely to be between 40 per cent. and 55 per cent. of the entire cost of the plant; if the net earnings are to be maintained above 7 per cent. plus depreciation then it is not warrantable to install an extension unless said extension will earn from 22 per cent. to 44 per cent. of the cost thereof.

These rules apply more particularly to private companies. A municipality often finds it desirable to lay an extension or pipe up a particular territory long before there are any improvements, but even in this case, the authorities must be assured that the revenue attainable will eventually pay so well that the present cost of the expenditure will be warranted. The same thing will apply to a private company, except that if a private company makes a wrong guess the results are financially disastrous while the municipality can easily absorb the mistake in general taxation.

REPORT OF THE TENTH NATIONAL CONFERENCE ON CITY PLANNING

ST. LOUIS, MO., MAY 27-29, 1918

By JOSEPH C. WAGNER, Member

THE Tenth National Conference on City Planning met at St. Louis, Mo., May 27-29, 1918. The attendance of about eighty delegates and others represented the Eastern and central Western States, the number being about equally divided between the cities east and west of the Mississippi River. Leaving out of consideration the local attendance from St. Louis, the larger Eastern cities sent two representatives to one from the trans-Mississippi section. The Conference as a national meeting, therefore, could not be considered eminently successful.

Zoning and war were the key words of the conference. The most important papers presented on the first topic were upon such subjects as "Industrial Zoning," "Residence Zoning," "An Industrial Survey of St. Louis," and "The St. Louis Plan."

It was impossible, and it was not desirable, to keep the subject of war out of the conference and the subjects bearing upon the present situation enlisted much interest. The subjects of "War Housing and Community Building," "Lessons from the Plans of the War Cantonments," "Waterways and City Planning," and "City Planning in the Allied Countries During the War," were presented by those actively and directly engaged in such matters at the present time for the United States Government.

In view of the preparation of a zoning or districting bill for the City of Philadelphia by the Zoning Commission and the interest in the subject evidenced by many of our own citizens, it may be well to set forth in more detail the ideas advanced in the several papers on the districting question.

Dr. Robert H. Whitten in his paper on "The Zoning of Residence Sections" states among other things that:

"The protection of the homes of the people is probably the primary purpose of use in districting. While many purposes are served by an orderly and well-thought-out plan of city building, a first consideration in such plan is that there shall be some separation between residential use, on the one hand, and all forms of trade and industry on the other. In providing for this separation, however, it is essential to remember that trade and industry form the basis of the city's growth and that the areas devoted to such use cannot be narrowly confined without stopping the normal growth of the city.

"A first essential in residence districting is, therefore, the determination of the location and extent of the areas that will be needed for trade and industry. But while trade and industry constitute the primary purpose for the bringing of people together in large cities, it is no less true that good home conditions are essential to the welfare and prosperity of the city. In fact, this war has shown that good housing is absolutely essential to efficient production. The city in the future will have to give much greater consideration to all questions affecting the homes of its people if it wishes to maintain its productive efficiency.

"Residence districts must not only be protected against invasion by trade and industry but they must be protected against a too intensive use of the land. We want our home sections to have as much light, air and garden space as is consistent with a plan for the convenient housing of the entire population for a considerable period of years within the areas accessible and appropriate for housing purposes. We want to distribute the population as much as practicable, but at the same time we do not wish to force people who for business or other reasons need to live close to the central business sections, either to pay very high rents or to go to much less convenient locations.

"This general problem of protecting the residential sections from mutually antagonistic types of residence use and of preventing congestion of population may be approached in four ways:

"1. Direct limitation of the type of dwelling.

"2. Limitation of the percentage of lot that may be covered and size of yards.

"3. Limitation of number of houses or families per acre.

"4. Requirement of a certain minimum land area for each family housed.

"1. Under the first method, that of direct limitation of the type of dwelling, a zone may be established limited to single-family detached houses; another zone for all classes of dwellings including apartment houses. This is a simple and direct method and one proposed in various drafts of zoning regulations now under consideration. It is the method to which we have become accustomed in private restrictive covenants.

"2. Limitation of the percentage of lot that may be covered and the size of yards. This is the method applied under the New York Building Zone Plan to protect high class single-family detached house sections. In the 'E' area districts residences are limited in general to an occupancy of 30 per cent. of the area of the lot and a side yard and large rear yard are required.

"3. Limitation of the number of houses or families per acre. In England, under the Town Planning Act, the number of houses or buildings per acre may be limited. Tho houses or buildings rather than families are referred to in the act, it is apparently being so administered as substantially to secure the limitation of the number of families per acre.

"4. Requirement of a certain minimum land area for each family housed. This method is intended to accomplish the same result and is in reality merely another way of stating the method just considered, *i.e.*, limiting the number of families per acre. It would require a certain minimum area of lot for each dwelling or for each apartment in case of a multi-family dwelling. Thus there might be a zone in which a minimum of 5000 square feet of land area per family would be required. This would mean the equivalent of a lot 50′ × 100′ for each family housed. Another zone might require 2500 square feet of land area per family, another 1250 square feet and so on. This would mean that taking a standard lot 50′ × 100′ in the first zone only a single family house could be constructed on such lot; in the second zone a two-family house could be constructed; in the third zone a four-family house and so on. This would provide for the varying intensities of use necessary in a city of the metropolitan class. It would afford the means of protecting the suburban residence sections, of securing an appropriate distribution of population and of preventing undue congestion in the central areas.

"This plan of requiring a minimum land area per family can be carried out under those statutes that have been passed authorizing zoning in the various States that have followed the general terms of the New York Charter Amendment of 1916. Future statutes, however, should include this power specifically, so there will be no doubt as to the legislative intent. Any residence zone plan that is based directly and consistently on the prevention of congestion of population is based on a purpose which the courts can scarcely fail to recognize as being within the plain scope of the police power."

Mr. Herbert S. Swan in his paper on "Industrial Zoning" stated that primarily districting must be elastic, but not at the expense of simplicity, as the latter must govern in order that practical results be obtained. In addition, in any use there should not be too great a multiplicity of kinds of use as tending to confuse by carrying the differentiation to too fine a distinction and thereby possibly failing to enlist the sympathy of the courts in the adjudication of contested cases. The law also must not be too arbitrary, as in any law there will always be cases on the border lines to which a hard and fast law will be difficult of application. It was suggested for this, the creation of a Board of Appeals to which all such cases might be referred for adjustment.

Mr. Swan assumed that it was necessary to district industry in the city as well as to separate residence from industry and commerce. "The competitive strength of a city commercially depends largely upon the proper arrangement of the industries within the city. Unnecessary hauling and heavy terminal charges react against the city's economic expansion and growth."

Regarding the number of classes of use—In the Los Angeles Ordinance there are two districts; in the residence district businesses not especially excluded are permitted and in the industry district all kinds of business and industry are unrestrained.

The residence district in the New York law excludes all business and industry and the business district large manufacturing and nuisances. The New York law does not protect sufficiently large manufacturing against nuisances, as they are both placed in the same classification. Manufacturing and nuisances should be separate from each other just as residence, business and manufacturing are separated. This the proposed St. Louis Ordinance endeavors to effect.

In the Berkeley Ordinance residences are prohibited in the manufacturing and nuisance district, and rightly so.

In all ordinances an extreme caution should be used in differentiating the classification in order not to invite unfavorable decision at this time from the courts for too arbitrary regulations. "The classification of industry must proceed upon a plan made only after a careful examination of the facts in each city rather than upon any theoretical principles. The number, however, should be kept down to the smallest working minimum essential to the carrying out of the primary objects of the plan.

"The form which factory districts should assume, whether they should be confined in the heart of the city, dispersed to the suburbs, segregated in concentric zones, laid out along lines radiating from the centre, arranged in parallel districts bisecting the city, or discriminately scattered thruout is one which as yet has not been satisfactorily answered." It may be that the most satisfactory method in one community would be the least satisfactory in another community.

The necessity for a constructive program for the industrial growth and future development in any large city in an orderly manner cannot now be questioned, and such a program cannot be made until the physical plan of such a city is thoroly and intimately studied and analyzed.

The subject of blighted districts in St. Louis, Minneapolis, and Philadelphia occupied one session, and tho the existence of such districts in every large city was deplored, the means to prevent seemed difficult to find. The shift of population from a purely and high-class residence district near the centre of the city by reason of the influx of trade or industry was often the cause of a blight. Where development is rapid, blight will always occur, and districting or zoning by law was advocated as the only remedy.

A large portion of the centre of St. Louis was given as blighted. Several blocks of built-up properties between the hotel district and the Union Station and beyond twenty-five or thirty years ago were high-class residences only, being large mansions and single-family houses built on large lots. Invasion has been made by commercial business and industry, and a congested colored population now occupies the old residences for apartments and tenements.

A blighted district in Minneapolis was shown of several blocks extent and near the city's business centre where the assessment values decreased over 35 per cent. in ten years.

We are all familiar with similar sections in our own city and in some instances a few of such districts are recovering their original values by change of use.

The city of St. Louis is embarking upon a comprehensive plan of development with the view of correcting some of the errors of the past and providing for a more orderly development for the future.

The new City Charter gives grants of larger and wider powers to the municipality.

" The city plan constitutes city policy in the guidance of physical and social growth." St. Louis needs a comprehensive city plan and is going about securing one.

The program provides separate studies of the street system, transit and transportation, markets, recreation, grouping of public buildings, districting and housing and street appearances. All these studies are to be finally correlated and revised into a comprehensive plan.

In the matter of districting or zoning, St. Louis has prepared the plans and is awaiting their enactment by Councils into law. On the question of use—the most important and probably the most difficult to determine—the classification follows generally the New York law except that there are First Residence Districts and Second Residence Districts.

In the First Residence Districts all buildings are to be designed, erected and used exclusively for single-family dwellings. In the Second Residence Districts, buildings are set aside for dwellings, tenements, hotels, lodging and boarding houses, churches, private clubs, hospitals and sanitariums, public and semi-public institutions and police and fire stations. All commerce and industry are excluded from both residence districts and private garages are permitted in both.

Use is further sub-divided into Commercial, Industrial and Unrestricted Districts.

In the Commercial Districts stores or shops for wholesale or retail business, places of amusement, office buildings and use permitted in the residence districts are allowed. Garages are also permitted, under certain restrictions.

Industrial Districts are established for the conduct of many and various specified trades and industries. Buildings designed or used for all other trades, storage, industry, commerce or residence may be erected in the Industrial District.

In the Unrestricted Districts, buildings may be erected and used without restriction as to the nature of their use.

As to the street plan of St. Louis the city limits are as they were in 1876, and in the oldest portion of the original city, especially that portion nearest the river front, the streets are thirty and forty feet wide. As the city expanded, street widths were increased so that to-day in the present downtown business district the principal thorofares are sixty and eighty feet wide, and three-fourths of the 940 miles of streets in the city are sixty feet wide. In the major street plan recommended for the city the minimum width for streets without trolley lines is fixed at sixty feet, and the minimum for streets with trolley lines is fixed at eighty feet, with a width of ninety-eight or one hundred feet to be adopted where possible. In the residential and commercial districts the eighty-feet width is divided twenty-eight feet for sidewalks and fifty-two feet for roadway, with a provision for twenty feet width for double-track trolley lines in the centre. The one hundred-feet-wide street is divided thirty-two feet for sidewalks and sixty-eight feet for roadway.

The basis of an excellent major street plan already exists in St. Louis. With widenings, extensions and connections, the system can readily be completed and at no great expense.

Some of these improvements are proposed and some are under construction. The main object of the several improvements is to provide easy access to the central business district and also to provide adequate and ready passage thru this district. The central business district has been defined as five blocks wide by eight blocks long and located in the old city proper about midway between the river and the Union Station.

One of the most important improvements in building and projected in the immediate present is the extension and widening of Twelfth Street, which is the western boundary of the defined business district. At present Twelfth Street is disjointed and of varying widths in its different lengths, and it is proposed to widen to eighty and ninety-eight feet, connecting the dead ends and by two short diagonal cuts connect two already existing radial avenues, leading into and out of the city from the north and from the south. This improvement will provide a much-needed main thru trafficway from either the north or south end of the city thru the business section and out again in the opposite direction to the city limits.

THE INCOME TAX

AN ENGINEER'S ANALYSIS WITH SUGGESTIONS

By CARL G. BARTH, Member

PART II*

IN Part I reference was barely made to "Pareto's Law," and its application in connection with the formula therein recommended for a graded income tax, to forecast the total amount of tax resulting from the adoption of specific values for the two constants α and a in the latter formula; namely,

$$T = \alpha \frac{C^2}{C + a} \quad \text{(IV)}$$

The consideration of this matter will now be taken up.

By a study thru a term of years, of the income tax returns of a number of European and other countries, the Italian economist Vilfredo Pareto has discovered that the distribution of a nation's total income among its breadwinners and others, enjoying incomes without working, is by no means a matter of chance only; but that, on the contrary, the same is subject to a fairly definite law—just the same as the distribution of the total number of deaths in a nation among its individuals of various ages, in normal times at least, follows a very definite law of averages, in spite of the part played by chance in the final distribution of deaths among the specific individuals of any one age.

However, just as the law of averages cannot operate satisfactorily among the few individuals that each year die at the highest ages attained by human beings, neither can it operate satisfactorily among the comparatively few individuals that enjoy the highest personal incomes.

For this reason Pareto's Law, in the first place, does not hold very closely for the highest individual incomes; besides which, as also pointed out by Pareto himself, it does not hold good for the smallest individual incomes enjoyed by the great majority of industrial workers, for which the United States particularly lacks the necessary statistical data, but which unquestionably are higher than a conformity to the law would indicate.

While thus Pareto's Law, in its exceedingly simple form, holds good only between certain rather indefinite limits of the higher and lower individual incomes—for the purposes of this paper, which is to point out the possibilities of going even further in the mathematical treatment of the subject under consideration than so far attempted by Pareto himself, rather than to claim any accuracy and immediate value for the figures finally arrived at—we will assume the law to hold good for all incomes.

In general, Pareto's Law is mathematically expressed by the formula

$$N = \frac{A}{C^n + h}$$

in which A is a constant for any one country at any one time in its economic development, C any individual income; the exponent n, a number which averages 1.5; h, another constant whose value is always small; and N, finally, the number of individuals that enjoy incomes in excess of C. Neglecting h entirely and assuming $n = 1.5$, we thus have

$$N = \frac{A}{C^{1.5}} \quad \text{(XI)}$$

From a study of a plot on logarithmic paper, made by the well-known economist, Professor Irving Fisher, of Yale University, of the income tax returns of the United States for the year 1916, published for the purpose of showing its conformity with Pareto's Law, I have written this law for the United States for that year as

$$N = \frac{120{,}000{,}000{,}000}{C^{1.5}} \quad \text{(XII)}$$

tho this formula gives values for C that are slightly greater than those called for by the statistics available to Professor Fisher, for the smaller incomes subject to the tax of 1916, while the conformity for higher incomes up to $1,000,000 per year, the highest plotted by him, is remarkably close.

About his plot, Professor Fisher says himself:

"This discrepancy is presumably because the persons returning income blanks and paying taxes on small incomes do not really represent the number of persons who should be paying taxes on these incomes; in other words, that at the border line between taxable and non-taxable incomes a considerable number of persons evade taxation, either thru direct intent or thru lack of realization that they should make returns."

We will now first derive a general formula for the total amount of a country's income, on the supposition that Formula (I) holds good for all incomes; as, of course, also done by Pareto himself.

In Fig. 1 formula (XI) is graphically represented by the curve,† for which incomes are represented along the base line, as abscissas, and corresponding values of N, vertically, as ordinates.

Now, just as N represents the number of incomes in excess of C, so $(N - dN)$ represents the lesser number of incomes in excess of $(C + dC)$; and hence, dN must represent the number of incomes between C and $(C + dC)$. But by making dC smaller and smaller the ratio $\frac{C}{C + dC}$ approaches 1 as a limit, so that, in the limit, we may finally write dN as representing the number of individual incomes of the magnitude C; and hence also $dZ = C.\ dC$, in which $dZ =$ the differential of the sum total of all incomes, and as such is represented by the shaded strip in the figure.

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* Part I published in the June JOURNAL.

† It must be realized that the curve cannot in reality be a perfectly smooth one, as N cannot vary by less than 1.

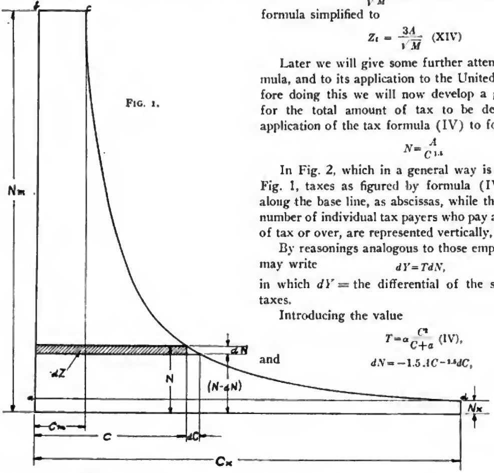

FIG. 1.

Differentiating equation (XI) we get

$$dN = d\,\frac{A}{C^{1.5}} = A\,dC^{-1.5} = -1.5\,AC^{-2.5}\,dC$$

which, introduced above, gives

$$dZ = C\,(-1.5\,AC^{-2.5})\,dC = -1.5\,AC^{-1.5}\,dC$$

Integrating between the limits $C = C_m$ and $C = C_x$, we now get

$$\overset{C_m}{\underset{C_x}{Z}} = -1.5\,A\int_{C_x}^{C_m} C^{-1.5}\,dC = -1.5\,A\left[\frac{C^{-0.5}}{-0.5}\right]_{C_x}^{C_m} = 3A\left[\frac{1}{\sqrt{C}}\right]_{C_x}^{C_m}\text{, or}$$

$$\overset{C_m}{\underset{C_x}{Z}} = 3A\left(\frac{1}{\sqrt{C_m}} - \frac{1}{\sqrt{C_x}}\right) \quad \text{(XIII)}$$

which formula thus gives the total of all incomes between a minimum C_m and a maximum C_x, and as such is represented by the area *abcd* in Fig. 1.

If in this we write M for C_m, to represent the very lowest income in a nation; and X for C_x, to represent the very highest; and we, for the purposes of this paper, assume formula (XI) to hold good between these extreme limits, then the total income of a country will be expressed by

$$Z_t = 3A\left(\frac{1}{\sqrt{M}} - \frac{1}{\sqrt{X}}\right)$$

in which the fraction $\frac{1}{\sqrt{X}}$ is always so small compared with the fraction $\frac{1}{\sqrt{M}}$, that it may be neglected, and this formula simplified to

$$Z_t = \frac{3A}{\sqrt{M}} \quad \text{(XIV)}$$

Later we will give some further attention to this formula, and to its application to the United States; but before doing this we will now develop a general formula for the total amount of tax to be derived from the application of the tax formula (IV) to formula (XI), or

$$N = \frac{A}{C^{1.5}}$$

In Fig. 2, which in a general way is quite similar to Fig. 1, taxes as figured by formula (IV) are laid out along the base line, as abscissas, while the corresponding number of individual tax payers who pay a certain amount of tax or over, are represented vertically, as ordinates.

By reasonings analogous to those employed above, we may write

$$dY = T\,dN,$$

in which $dY =$ the differential of the sum total of all taxes.

Introducing the value

$$T = \alpha\frac{C^2}{C+a} \quad \text{(IV)},$$

and

$$dN = -1.5\,AC^{-2.5}dC,$$

we then get

$$dY = \alpha\frac{C^2}{C+a}\left(-1.5\,A\;C^{-2.5}\,dC\right) = -1.5\,\alpha A\,\frac{dC}{\sqrt{C}\,(C+a)}$$

which, integrated between the limits $C = C_m$ and $C = C_x$, corresponding to $T = T_m$ and $T = T_x$ in the figure, becomes

$$\overset{C_m}{\underset{C}{Y}} = -1.5\,\alpha A\int_{C_x}^{C_m}\frac{dC}{\sqrt{C}\,(C+a)}{}^{*} = -1.5\,\alpha\,A\left[\frac{2}{\sqrt{a}}\tan g^{-1}\sqrt{\frac{C}{a}}\right]_{C_x}^{C_m} =$$

$$\overset{C=C_m}{\underset{C_x}{Y}} = -\frac{3\,A\alpha}{\sqrt{a}}\left(\text{tang}^{-1}\sqrt{\frac{C_m}{a}} - \text{tang}^{-1}\sqrt{\frac{C_x}{a}}\right) =$$

$$\overset{C_m}{\underset{C_x}{Y}} = \frac{3\,A\alpha}{\sqrt{a}}\left(\text{tang}^{-1}\sqrt{\frac{C_x}{a}} - \text{tang}^{-1}\sqrt{\frac{C_m}{a}}\right) \quad \text{(XV)}$$

This formula, then, gives us the sum total of all taxes levied by formula (IV), between a minimum income C_m and a maximum C_x.

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*To solve this integral, put $x = \sqrt{\frac{C}{a}}$, $\sqrt{C} = \sqrt{a}\,x$, $C = a\,x^2$ and $dC = 2\,ax\,dx$, and we have

$$\int\frac{dC}{\sqrt{C}\,(c+a)} = \int\frac{2\,a\,x\,d\,x}{\sqrt{a}\,x\,(a\,x^2+a)} = \frac{2}{\sqrt{a}}\int\frac{dx}{1+x^2} = \frac{2}{\sqrt{\alpha}}\text{tang}^{-1}x = \frac{2}{\sqrt{a}}\,\text{tang}^{-1}\sqrt{\frac{C}{a}}.$$

If we here also write M for C_m and X for C_x, to represent the extremes in individual incomes in a nation, then the total tax of that nation when levied by formula (IV) becomes

$$Y_t = 3A \frac{\alpha}{\sqrt{a}} \left(\text{tang}^{-1} \sqrt{\frac{X}{a}} - \text{tang}^{-1} \sqrt{\frac{M}{a}} \right) \text{(XVI)}$$

Now, while neither formula (XIV) nor formula (XVI) can absolutely express what they are here purported to do, because, as fully stated earlier, Pareto's Law does not hold good for the smallest incomes of a nation, formula (VIII) must necessarily be more nearly what it purports to be than the other two, because of the exceedingly small percentage of tax formula (IV) levies on small incomes.

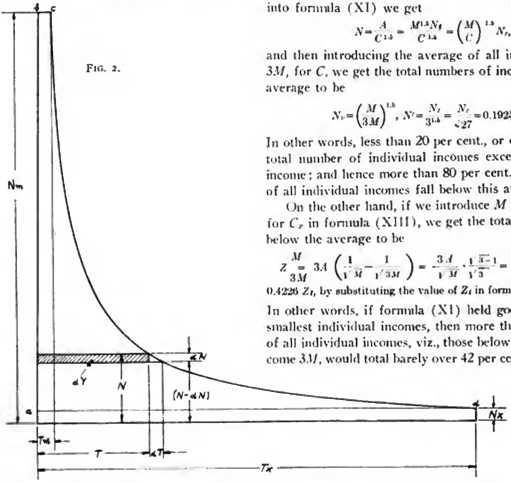

FIG. 2.

However, as there is nothing better at present in sight to go by, we will for the time being have to accept all three formulæ as sufficiently correct for the purposes of this paper.

Designating the total number of a nation's breadwinners, and others enjoying individual incomes without working directly, by N_t, we may first solve formula (IV) with respect to C and write

$$C = \left(\frac{A}{N}\right)^{\frac{2}{3}},$$

and then write

$$M = \left(\frac{A}{N_t}\right)^{\frac{2}{3}} \text{(XVII)}$$

Solving (XVII) for A, we get

$$A = M^{1.5} N_t, \text{(XVIII)}$$

which introduced in (XIV) gives

$$Z_t = \frac{3M^{1.5} N_t}{\sqrt{M}} = 3M\, N_t \text{ (XIX)},$$

which divided by N_t, gives the average of all incomes in a nation to be $3M$, or only three times the minimum.

Introducing now the expression for A in (XVIII) into formula (XI) we get

$$N = \frac{A}{C^{1.5}} = \frac{M^{1.5} N_t}{C^{1.5}} = \left(\frac{M}{C}\right)^{1.5} N_t,$$

and then introducing the average of all incomes, namely $3M$, for C, we get the total numbers of incomes above the average to be

$$N_v = \left(\frac{M}{3M}\right)^{1.5}, N^t = \frac{N_t}{3^{1.5}} = \frac{N_t}{\sqrt{27}} = 0.1925\, N_t.$$

In other words, less than 20 per cent., or one-fifth, of the total number of individual incomes exceed the average income; and hence more than 80 per cent., or four-fifths, of all individual incomes fall below this average.

On the other hand, if we introduce M for C_m and $3M$ for C_x in formula (XIII), we get the total of all incomes below the average to be

$$Z_{3M}^{M} = 3A \left(\frac{1}{\sqrt{M}} - \frac{1}{\sqrt{3M}}\right) = \frac{3A}{\sqrt{M}} \cdot \frac{\sqrt{3}-1}{\sqrt{3}} = \frac{3A}{\sqrt{M}} \cdot 0.4226 =$$

$0.4226\, Z_t$, by substituting the value of Z_t in formula (XIV).

In other words, if formula (XI) held good down to the smallest individual incomes, then more than 80 per cent. of all individual incomes, viz., those below the average income $3M$, would total barely over 42 per cent. of a nation's total income, while the remaining 58 per cent. of this total income would be enjoyed by the remaining 20 per cent. of income makers.

The actual truth is evidently not quite so bad, because formula (XI) does not fully represent the incomes of the masses, but it is undoubtedly near enough true to indicate in the clearest possible manner the enormously unequal distribution of a nation's total income.

However, as the average income $3M$ is only three times the minimum M, we readily realize the futility of materially adding to the prosperity of the masses by merely striving for a more even distribution of a nation's total income at the present time; and the only remedy for the pitiably small incomes of the masses, therefore, as often enough pointed out, but never accepted by the average labor leader and social worker, lies in the direction of increasing the productive efficiency of the industrial worker, who must himself create the wealth he wishes to, and should he able to, enjoy,— and "then some," for a reserve to carry him over a "cold day," and for the natural expansion of his country's industrial and other activities.

We will now proceed to arrive at some idea of the magnitude of the minimum income M for our own country by supposing that formula (XI) as written

$$N = \frac{120{,}000{,}000{,}000}{C^{1.5}} \quad \text{(XII)}$$

holds good down to this minimum. We can do this on the supposition that there is one family for every five of the 100,000,000 inhabitants of the country, and thus 20,000,000 families all told; and that there are two breadwinners for each family, or 40,000,000 breadwinners in all, which is the best I have been able to learn about this matter.

We then have

$$40{,}000{,}000 = \frac{120{,}000{,}000{,}000}{M^{1.5}}, \text{ or } M = 3000^{\frac{2}{3}} = \$208$$

Hence the average income of all breadwinners of the country, viz.,

$$3M = 3 \times \$208 = \$624$$

The minimum income of a family thus becomes $208 × 2 = $416, and the average income of all families becomes $624 × 2 = $1248. Let us hope and pray that formula (XII) is enough out of the way for the smaller incomes, so that carefully compiled statistics will prove these to be considerably higher than these figures indicate, not only under the present abnormal conditions, but also for more normal conditions.

However, as we can do no better for the present, let us introduce this value 208 for M in formula (XIV) as written

$$Z_t = \frac{360{,}000{,}000{,}000}{C^{0.5}}$$

for our country in 1916, for which we have taken $A = 120{,}000{,}000{,}000$; and we figure the total income of the country for 1916 to have been

$$Z_t = \frac{360{,}000{,}000{,}000}{\sqrt{208}} = 24{,}960{,}000{,}000$$

or about 25,000,000,000, as against 28,000,000,000 estimated as our national income for the year 1913, according to a statement by Charles A. Gilchrist of the University of California in an article that appeared in "The Scientific Monthly" for October, 1916. On submitting these figures to Professor Fisher, his comment was that the discrepancy is well explained by the comment often enough made above, on the breakdown of Pareto's Law and formula (XI), for the smaller incomes, the totals of which we have seen amount to a large portion of the total of all incomes. The breakdown of the law for the few largest incomes has no appreciable influence on the total of all incomes, while it does have some on the total of all taxes on incomes.

For the purpose of estimating the total income tax that might have been levied for 1916 by formula (IV), with the values

$$\alpha = \tfrac{2}{3} \text{ and } a = \$275{,}000, \text{ or } T = \tfrac{2}{3}\,\frac{C^2}{C + 275{,}000^2}$$

we must first estimate the one maximum income of that year. This we do by substituting the value 1 for N in formula (XII) and thus write: $1 = \frac{120{,}000{,}000{,}000}{X^{1.5}}$, which gives

$$X = 120{,}000{,}000{,}000^{\frac{2}{3}} = 24{,}329{,}000.$$

By now substituting $\alpha = \frac{2}{3}$, $a = 275{,}000$, $A = 120{,}000{,}000{,}000$, $M = 208$, and $X = 24{,}329{,}000$ in formula (XVI), we get the total tax we are after, to be

$$Y_t = \frac{360{,}000{,}000{,}000 \times \frac{2}{3}}{\sqrt{275{,}000}} \left[\text{tang}^{-1} \sqrt{\frac{24{,}329{,}000}{275{,}000}} - \text{tang}^{-1} \sqrt{\frac{208}{275{,}000}}\right]$$

$$= 457{,}666{,}500 \left[\text{tang}^{-1}\, 9.4058 - \text{tang}^{-1}\, 0.0275\right]$$

$$= 457{,}666{,}500 \left[83^\circ.932 - 1^\circ.575\right] \frac{\pi}{180^\circ} = 657{,}846{,}000.$$

If levied by the formula

$$T = \tfrac{2}{3}\,\frac{C^2}{C + 200{,}000} \quad \text{(VI)}$$

the one tentatively suggested for single men, the total tax would figure

$$Y_t = 786{,}500{,}000.$$

Neither of the two amounts obtained is likely at all to approach the actual taxes on incomes collected for 1917, for several reasons:

First, the total of all incomes of the country in 1917 undoubtedly greatly exceeded that of 1913. Second, neither of the tax formulæ applied would levy as much as the law, except for the higher incomes. Third, the formulæ are entirely aside from the excess-profit taxes, which must have totalled in big figures.

However, this has no bearing on the value and importance of the efforts of this paper, which have been made for the purpose of pointing out what may be done to simplify the mathematical part of the problem of taxation, when once complete and reliable statistics are available.

SOME FUNDAMENTALS OF AVIATION

(*Continued from Page 336*)

about as fast as their pilots' hearts can stand, and the things that planes are doing and are able to do and the things that are developing will, after the war, make the most interesting reading of anything, I think, that has been done during the war. I remember during the first few weeks of the war we would see a couple of lines in the paper stating that aeroplanes had been used for scouting along the battle front. I picked up a paper the other day and practically the whole front page was devoted to aeroplane news. I do not need to explain to you the importance of the aeroplane—how important it has become in war nor the tremendous number of new uses that it is being put to; but I do want to say this, that especially in connection with the aeroplane industry, American ingenuity is going to have the greatest influence on the war. One of the most radical and the most beneficial developments which have come to us for some time as a method of killing Germans is something which applies to aerocraft.

The members of the Society of Automotive Engineers are doing some very real things along the line of ingenuity and design for the winning of the war.

RADIUM AND RADIO-ACTIVITY *

By **CHARLES H. VIOL**

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LIKE so many of the great discoveries, the discovery of that property of matter called "radio-activity" was the result of an accident. In 1896 the French physicist, Becquerel, was investigating the effect of the fluorescent light of uranyl potassium sulphate upon photographic plates enclosed in a light-proof cover. One cloudy day the uranium salt was laid upon the covered plate in a drawer to await a day when the salt might be excited to fluorescence by the action of sunlight. Several days later, when a new plate was put into the holder and the old one developed, to his great surprise Becquerel found that in the closed dark drawer the unexposed salt had strongly affected the photographic plate, causing a very dark spot. Numerous experiments convinced Becquerel that he had discovered a new property of matter, and careful investigation showed that this property of affecting the photographic plate was peculiar to the element uranium, the effect being proportional, ordinarily, to the uranium content of the various salts which were used.

This property of spontaneously sending out energy in the form of rays which, like the X-rays, penetrate thru matter and cause such changes, has been called radio-activity, and the rays of these substances sometimes are called Becquerel rays. Later Becquerel found that the rays of uranium cause also the discharge of electrically charged bodies, and Rutherford showed this to be due to the ionization of the gas thru which the rays pass. These phenomena were most remarkable, as they seemed to be due to a substance able to give out energy in the form of these rays without undergoing any change or receiving energy in any ordinary form.

The photographic effect and the ionization of gases furnish very delicate tests of radio-activity, the photographic being a qualitative test, whereas the electrical method may be quantitative. Gases ordinarily are nonconductors of the electric current, but when acted on by the Becquerel rays, the molecules of the gas are split into electrically charged parts or aggregates called ions. The simplest form of instrument for measuring the intensity of the ionization of a gas, which is a measure of the intensity of the radiations of a radio-active substance, is some form of a leaf electroscope. A very thin, narrow strip of metal foil, gold, silver or aluminum, is attached by its upper end to a well-insulated vertical metal support which is contained in a metal case, suitably provided with windows for observing the leaf. When a charge of electricity is communicated to the leaf system, the charge on the leaf is repelled by the charge on the metal support and the leaf moves out towards a horizontal position like an inverted L. This repulsion is proportional to the charge on the leaf system. If a radio-active substance causes the air in the electroscope to be ionized, that is, to become a conductor, the charge leaks away and the leaf moves back to a vertical position. By means of a reading microscope and scale, the rate of movement of the leaf may be observed. This rate is proportional to the intensity of ionization of the gas. If the instrument is calibrated, the result may be expressed as a current, since a current is the rate of passage of a quantity of electricity. These ionization currents are exceedingly small, that due to a square centimetre of metallic uranium being 0.00000000000026 ampère. But activities of the order of 1-100th that of uranium may readily be detected by this method.

Uranium is not the only radio-active element, for soon after, in 1898, Schmidt and, independently, Mme. Curie found that the element thorium was radio-active, its activity being a little less than that of uranium. Madame Curie, in studying the various minerals by an electrical method, found that certain of these were more active than metallic uranium, which was supposed to be the most highly radio-active substance. On separating the uranium from these minerals, it was found to have its normal activity and so it was concluded that the minerals must contain a more highly active substance. In a chemical investigation of the residues from the most active of these minerals, a pitchblende from St. Joachimsthal in Bohemia, Madame Curie discovered that the bismuth in the mineral, when separated, possessed a considerable activity. To this new substance she gave the name polonium. Shortly afterward, Professor and Madame Curie and G. Bemont found that there was another radio-active substance, which remained with the barium from the pitchblende. This barium salt was converted into barium chloride and subjected to a process of fractional crystallization, resulting in a concentration of the radio-active substance, which was found to possess (in a pure state) an activity several million times that of uranium. This substance was called radium. Later, Debierne obtained another active product from pitchblende, which he called actinium.

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* Presented before the Philadelphia Section, American Chemical Society, January 18, 1918, at the Engineers' Club.

Working with the radio-active substances, other interesting properties were discovered—one, in their ability to cause many substances, such as barium-platinocyanide and Sidot's hexagonal blende (a form of zinc sulphate), to become luminous. Curie and Laborde found that radium salts are continuously giving off heat in sufficient quantity to keep the salt several degrees warmer than the surroundings. In one hour one gram of radium evolves sufficient heat to warm 134 grams of water thru one degree centigrade (134 calories). Walkhoff, Giesel, Curie, Becquerel and others found that radium rays produce burns on the skin, much the same in character as those caused by X-rays, and it is well known what important and wide application this property, carefully controlled, has found in dermatology and in the treatment of malignant growths.

It may easily be shown by means of an electroscope that the radiation from uranium, polonium, radium and actinium is not homogeneous. A very thin layer of radium salt exposed in an electroscope produces a very intense ionization, so that the charged leaf moves rapidly. If the salt is covered with a thin metal sheet (say 0.006 cm. of aluminum) or mica, or a sheet of ordinary writing paper, the ionization is found to be only a few per cent. of that due to the freely exposed salt. If a second sheet is applied, the ionization is only a little less than that with one sheet. With ten such sheets, the ionization is reduced to about one-half that observed with one sheet. This is due to the fact that the first sheet cuts off completely some rays which have a greater ionizing effect. The residual ionization is due to a penetrating type of rays. With very great thickness of metal screening the radium preparation, there is found to be a very penetrating radiation which produces an ionization of the order of one ten-thousandth of that due to the free exposed salt. The readily absorbed rays have been called the alpha rays, those of intermediate penetrating power the beta rays, and the very penetrating radiation the gamma rays.

The alpha rays produce by far the greatest ionizing effects in gases, altho after passing thru a few centimetres of air, they are completely absorbed. They have been shown to be positively charged helium atoms, shot out with a velocity of about 12,000 miles per second (1-15th the velocity of light). Due to this velocity and the comparatively great mass of the particles, it is only with the most intense electric and magnetic fields that deviations of these rays could be produced. The deviations, however, proved that the particles are electrically charged, for a moving charged body will always be deflected from its path when passing thru a sufficiently intense electric or magnetic field, whereas an uncharged body does not change the direction of its motion. Crookes, using a lens, found that the light of phosphorescent zinc sulphide made luminous by the rays of radium, consisted of numerous flashes of light. The spinthariscope is an instrument which he devised to show these scintillations. A small speck of radium or other highly radio-active material is supported a few millimetres above a zinc sulphide screen fixed in one end of a tube, which contains a lens at the other end. In a dark room, the screen is seen as a dark field dotted with brilliant flashes of light, which come and go rapidly. This experiment very vividly impresses the observer with the fact that the radio-active material is continually shooting out particles, whose impact with the screen is marked by a spark of light. This effect was found to be due to the alpha particles; for, if the radium was moved away a few centimetres, or if it was screened with a very thin paper, the scintillations cease. The length of a path thru which an alpha particle produces its characteristic effects of ionization, photographic effect, scintillations, etc., is called its range. The ranges of the alpha particles of the various active substances have been measured and are found to be different for the different elements. The range of the alpha rays of radium is 3.3 cm. in air. This means that at a distance greater than 3.3 cm. from a radium preparation there will be no ionization in air, so far as the alpha rays are concerned, and no scintillations on a phosphorescent screen.

The great energy with which the rays are shot out is the source of the heat that all radio-active bodies produce, for on stopping the alpha rays their extra energy finally is converted into heat. The alpha particles produce the greatest heating effect, furnishing 123.6 calories of the 134 calories which one gram of radium produces in an hour. The effect of alpha rays on the skin, because of their ready absorption, is confined to a thin surface layer, and, depending upon the activity of the preparation and the time of exposure, the effect varies from a faint reddening to an intense necrosis.

The beta rays are about a hundred times more penetrating than the alpha rays and have been found to be of the same type as the cathode rays. They are negatively charged particles, having a mass of 1/6800th that of alpha particles, and their velocity is of the order of that of light. The total ionization which the beta rays of radium produce in gases is about 3 per cent. of that due to the alpha rays, the heating effect being also of this order, since the beta rays furnish 4.3 calories of the 134 calories given off per hour by one gram of radium. The beta rays of radium are nearly completely absorbed by eight millimetres thickness of aluminum or two millimetres of lead. Roughly, it may be assumed that the thickness of matter required to absorb any type of rays is inversely proportional to the density of the substance, or that the absorption is proportional to the density. Beta rays are more energetic in their action on the photographic plate than are alpha rays, but while they excite phosphorescent substances, the effect is generally much less than that due to alpha rays. Changes in coloration take place when many substances are exposed to the action of the rays—but here again the effects of beta and gamma rays are usually much less than those of the alpha rays, altho in the latter case the change is limited to a surface layer, whereas the change due to beta and gamma rays penetrates deeper. Some kinds of glass at first become violet, and on longer exposure almost black. The rays cause many chemical changes to take place. They ozonize the air, and under the action of its own rays, the solid bromide of radium exposed to air decomposes its water of crystallization into oxygen and hydrogen; the salt loses bromine and is slowly converted into a carbonate. Under the influence of the beta and gamma rays of radium, hydrogen and chlorine combine to form hydrochloric acid, and water is decomposed to give hydrogen and hydrogen peroxide. The physiological effects of the beta and gamma rays—while not so intense as those of the alpha rays from a given amount of radium—because of the greater penetrating power of the beta and gamma rays, find very useful application in the treatment of many forms of skin diseases, tumors, etc.

The gamma or very penetrating rays are ether vibrations analogous to the X-rays, but these rays are much more penetrating than the X-rays produced in a "hard" vacuum tube, and they are from ten to one hundred times more penetrating than the beta rays. The total heat effect of the gamma rays of radium is about of the same magnitude as that due to the beta rays. The gamma rays are not deviated by the electric or magnetic field. They are closely related to the beta rays, since they are capable of being transformed into beta rays. It is quite probable that their ionizing effects in gases are due to the secondary beta rays, which the gamma rays produce. The gamma rays of radium are half-absorbed after passing thru 115 metres of air. Due to the gamma rays, a delicate electroscope could readily show the presence of one gram of radium more than 100 metres distant. The gamma rays of radium are absorbed to the extent of about 40 per cent. after passing thru one centimetre of lead; and after passing thru ten centimetres of lead, there is still 0.6 per cent. unabsorbed.

Gamma rays from 30 milligrams of radium can still be detected by means of an electroscope after passing thru a foot of iron. As it is difficult accurately to measure the current due to the intense ionization produced by larger quantities of radium (quantities of the order of one milligram or more), it is now the practice to compare such quantities of radium by means of their gamma-ray ionization current. The international gamma-ray radium standard was prepared by Mme. Curie by carefully weighing out a quantity of pure, dry radium chloride, and standards prepared by comparison with this international standard furnish the means of estimating accurately larger quantities of radium.

The first experiments with uranium, thorium and radium showed that the activity of these substances was spontaneous, and since no change in the intensity of the radiations was found, when observations were made during a period of several years, it was supposed that this activity was permanent. In 1899 and 1900 some observations were made which indicated that some radio-active substances may lose a part of their activity in a very short time. The activity of uranium had been found by Becquerel and Mme. Curie to be an atomic property, unaffected by the chemical combination of uranium with other elements. In 1900 Sir William Crookes found that by a single chemical operation he could separate from uranium a very minute quantity of a substance, free from uranium, which, as measured by its effect on the photographic plate, was hundreds of times more active than an equal weight of uranium. This substance he called uranium X, the "X" indicating, as in algebra, an unknown. Becquerel found another method for separating uranium X from uranium, by precipitating barium sulphate in a solution of uranium salt, the barium sulphate carrying down the uranium X, leaving a uranium solution that was inactive (photographically). A year later he found the barium sulphate was quite inactive and that the uranium had regained its activity. Rutherford and Soddy found it possible, by a single operation, to separate a substance from thorium which in cases was thousands of times more active than an equal weight of thorium. This substance they called thorium X. In the case of thorium it was not possible completely to remove all the activity, a limit being reached when the activity of the thorium was reduced to about one-third of its initial value. In a month after its preparation thorium X was found to be inactive, and the thorium, from which it had been separated, had regained its normal activity. Accurate electrical measurements of the alpha-ray activity of thorium X and thorium, free from thorium X, showed that the former product lost its activity at the same rate that the thorium regained its activity, so that in four days half the activity of the thorium X was gone, and the thorium had regained half of its lost activity. In another four days half of the remaining activity of the thorium X was lost and the thorium had regained a corresponding amount, and so on, until by the end of the month the thorium X was practically inactive, and the thorium had regained its original activity. Similar measurements on the beta rays of uranium X (the beta rays are much more active photographically than the alpha rays, so that in Becquerel's work the uranium, free from uranium X and producing only alpha rays, was inactive, in comparison with the uranium X, which produces the photographically active beta and gamma rays) showed that the uranium X lost half of its activity in about twenty-five days, and that the uranium recovered half of its lost activity in the same time.

The velocity of all ordinary chemical reactions may be varied by suitably varying the conditions of temperature, concentrations of reacting substances, etc.

Hydrogen and oxygen gas may be mixed at ordinary temperatures and the velocity of formation of water, due to their chemical combination, is exceedingly small. But if the mixture is heated the velocity of reaction becomes so great that the combination takes place with explosive violence. In case of radio-active changes, it has been impossible, so far, to change in the slightest degree the rate at which the change of activity of the different substances is taking place. In the heat of the electric furnace or the cold of liquid air, in a state of high concentration, or when mixed with enormous quantities of other forms of matter, the uranium X and thorium X, in fact, all radio-active substances, as we shall see, undergo a loss of activity at a definite rate which is characteristic for each of the substances. The time required for the activity of a quantity of a definite radio-active substance to fall to half its initial value, as measured, for example, by its saturation ionization current in an electroscope, is called the "half-value period," or, briefly, its period. Radioactivity is due to a spontaneous production of new forms of active matter, as, for example, uranium X from uranium, and the laws which control this production differ from the laws governing ordinary chemical reactions, since by no known means can the rate of formation or decay of the activity of the radio elements be influenced. The alpha, beta, and gamma rays, and the very considerable quantities of energy with which their rays are endowed, must also be accounted for.

In 1903 Rutherford and Soddy advanced the hypothesis that the atoms of the radio-active elements are suffering spontaneous disintegration and that each atom so changing passes thru a well-defined series of changes, accompanied usually by the emission of an alpha ray. This theory supposes that on an average, in a given time, a certain definite fraction of all the atoms of any radio-active substance become unstable and these atoms break up. This process of disintegration of the atoms is very violent, and usually results in the throwing off of an alpha particle with great velocity. In the case of some substances, as, for example, uranium X, the atom gives off a beta particle and gamma rays. We may view the formation of uranium X from uranium, and thorium X from thorium from the standpoint of the corpuscular theory of matter. Some of the uranium atoms become unstable and disintegrate, each one shooting out an alpha particle and leaving an atom of uranium X. Only an exceedingly small fraction of all the uranium atoms present undergoes this change in any short interval, and this very slow decay of the uranium makes the activity of the uranium, as measured by the ionization current due to its alpha rays, sensibly constant. The half-decay period of uranium is estimated to be about 5,000,000,000 years.

In a given quantity of uranium there are being produced every second a certain definite number of atoms of uranium X. If the uranium is initially freed from uranium X by any suitable chemical means, there will be formed in the first second this same definite number of uranium X atoms, and of these a certain proportion will be changed into the next product—but not all will change. In the next second more uranium X atoms are formed, and since there are now these together with the uranium X atoms which did not disintegrate in the preceding second, the number which do change in the second second is greater, since this number is always the same definite fraction of the total number of uranium X atoms present. This process of piling up of uranium X atoms goes on until the number of uranium X atoms changing in an instant is equal to the number of these which are formed per instant from the uranium. This limiting condition is called that of radio-active equilibrium. The exact mathematical development of this state of radio-active equilibrium enables us to calculate the quantity of uranium X which is in equilibrium with a quantity of uranium, this being about one hundred-millionth of a gram of uranium X for a kilogram of uranium. Thorium, which is decaying with a period of about 13,000,000,000 years, gives rise to the thorium X in a similar manner. The remarkable amounts of energy which are associated with radio-active changes may now be accounted for. It comes from the stores of energy that are within the atoms of the transmuting elements. The total extent of this internal energy we can only speculate about, but its probable magnitude may be comprehended when it is understood that the energy changes involved in the complete disintegration of one gram of radium equals the heat energy evolved when half a ton of coal is burned. More than 20,000 years are required for the complete disintegration of a quantity of radium, so that the energy is liberated rather slowly, and the cost of radium makes the application of very large amounts of "radio-active" energy almost prohibitive.

In 1899 Owens found that the activity of thorium compounds seemed to be variable, if a current of air were passed over the substances. A steady stream of air was found to reduce the activity markedly. Rutherford investigated this peculiar effect, and decided that the thorium was continually giving off radio-active particles which possess the property of ionizing gases acting on the photographic plates, and of rapidly diffusing thru porous materials like paper. This substance he called the thorium "emanation," from its gas-like behavior. Special experiments showed that this substance really is radio-active matter that is gaseous. The thorium emanation must not be confused with the alpha, beta and gamma rays. The emanation is a form of radio-active matter that gives off alpha rays in the process of its disintegration. Being a gas, the emanation can easily be blown away in a current of air, and this explains Owens' first observations on the variation of the activity of some thorium compounds. The passage of active matter thru porous materials is also explained in this way. The thorium emanation, like thorium X and uranium X, decays in a comparatively short time, its period being 54 seconds, so that in ten minutes after separating the emanation, practically all of it has decayed.

Shortly after the discovery of the thorium emanation, Dorn found that radium also gives rise to a characteristic radio-active gas, which from analogy is called the radium emanation. Thorium emanation and radium emanation are given off only very slowly from the solid thorium and radium salts, but when these are strongly heated or are dissolved the emanations are given off quite freely. The period of radium emanation is 3.85 days, and radium free from its emanation will again produce the equilibrium amount of emanation if sealed for about thirty days. Radium emanation is a chemically inert gas of the argon type. Like radium, it shows a characteristic spectrum, and, when strongly cooled, it condenses at –150° C. Diffusion experiments showed that it was a gas of very high atomic weight, and in 1911 R. W. Gray and Sir W. Ramsay actually determined its atomic weight by weighing a known volume of pure emanation. From their results, the atomic weight was found to be 223. The atomic weight of radium is 226.4, and in changing into the emanation one alpha particle (helium atom) is lost from the radium atom. The atomic weight of helium is 4, so that it is to be expected that the emanation would have an atomic weight of 222.4. Some idea of the delicacy of the work of Gray and Ramsay may be obtained when it is known that the weight of emanation used in their experiments was less than one-thousandth of a milligram, that the glass vessels containing the emanation weighed about thirty milligrams, and that the microbalance on which the weighings were made was sensitive to about one-millionth of a milligram. Gray and Ramsay have suggested the name "niton" (which is Greek for "the shining one") for the radium emanation, since it now may be definitely admitted to be an element, and a higher analogue of the "noble gases," helium, argon, neon, krypton and xenon. The amount of radium emanation in equilibrium with one gram of radium element is called the "Curie," and has been found to occupy a volume under normal conditions of temperature and pressure of 0.6 cubic millimeter, and to have a weight of 0.006 milligram. So delicate are the electroscopic methods for detecting radium emanation that radium emanation from one hundred-millionth of a gram of radium gives a readily measurable rate of discharge in an electroscope. The luminescence produced by the action of the alpha rays from radium emanation, when exposed to a zinc sulphide screen, is very marked, for example, passing 000.6 milligram of radium emanation into a cylindrical glass vessel having walls coated with a thin layer of phosphorescent zinc sulphide leads to the production of an intense luminescence which can readily be seen in a darkened room for a distance of fifty feet or more.

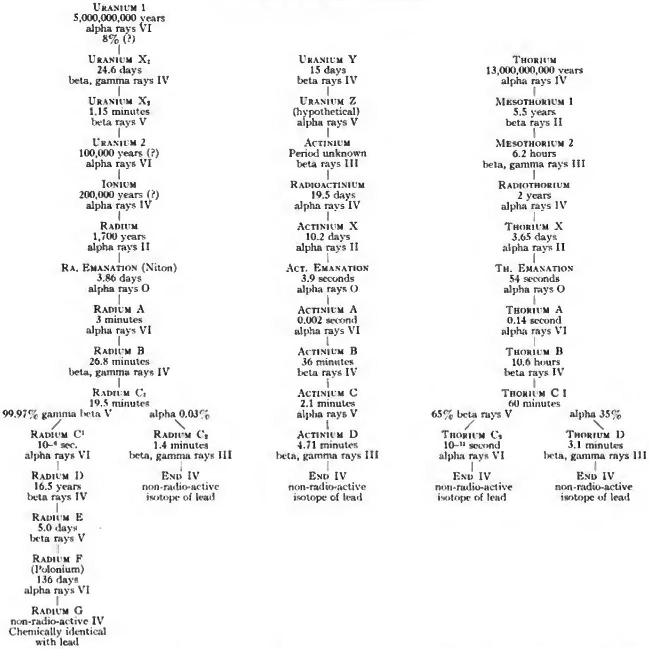
A very remarkable property of radium and thorium is the ability to cause bodies which are exposed to them to become temporarily radio-active. A piece of metal foil exposed to thorium hydroxide for several hours behaves, after removal, as tho it were radio-active. This activity was at first called "induced," or "excited," activity, since it was thought that the exposure to the radio-active substances actually caused ordinary matter to become temporarily active. This effect is now known to be the result of a deposit of radio-active matter on inactive bodies, and this radio-active matter is called the "active deposit." Matter exposed to radium receives the characteristic radium "active deposit." The source of these active deposits is the gaseous radio-active matter or emanations which thorium and radium produce. The emanations diffuse into the air around the preparations, and in decaying give rise to other radio-active matter, which, not being gaseous, collects on whatever objects may be about, and constitutes the "active deposit." The periods of these active deposits have been measured and are found to be 26.8 minutes for the radium deposit, and 10.6 hours for the thorium deposit.

The work of a great many experimenters has shown that these active deposits are complex, consisting of a mixture of various successive radio-active products. The various products in an active deposit exhibit characteristic chemical and physical properties, and, by taking advantage of these, separations of the various forms of radio-active matter in the deposit may be effected. These products are always present in unweighably small quantities (due to their short periods), and so these separations must always leave the radio-active material mixed with certain quantities of ordinary inactive matter necessary in order that there may be something tangible with which to work. The active deposit of thorium, collected on a platinum plate, may be dissolved in acid or volatilized by heating the plate to a white heat. In the radium series the first product from the emanation, called radium A, has a period of three minutes. This radium A in disintegrating forms what is called radium B, a product that has a period of 26.8 minutes. Radium B gives rise to beta rays and the product radium C. Radium C, decaying with a period of 19.5 minutes, produces alpha, beta and gamma rays and radium D. Radium D has a longer period, 16.5 years, so that while the active deposit on a substance which has been exposed to radium emanation at first decays rapidly—due to the short periods of radium A, B, and C—there is left a slight residual activity, due to the slow decaying D, and the subsequent products radium E and radium F. The period of radium E is five days, and that of radium F is 136 days. Radium F gives off alpha rays, and we now know that the product which Mme. Curie first isolated with the bismuth from pitchblende residues, and called polonium, is nothing other than radium F, that accumulates in the pitchblende.

The radio-elements now known number about thirty, and may be grouped into three families—the uranium-radium group, the actinium group, and the thorium group.

Since the half-decay period of radium is about 1700 years, it is evident that in about 20,000 years practically all the radium now existing will have transmuted, and, in order to account for the presence of radium to-day, a longer-lived product must be sought. This parent is the element uranium. A number of researches, beginning with the work of Boltwood, McCoy, and of Strutt, have shown that there is a relation between the amount of radium and of uranium in most uranium minerals. Experiments were carried out to test whether the newly-formed radium could be detected in uranium initially freed from radium. The experiments gave negative results, and Boltwood found that there is a long-lived product, ionium, in the series between uranium X and radium.

Table of the Radio-elements



Actinium is always found in the uranium minerals, and its origin is obscure, tho it seems probable that it results as a branch product in the uranium series. That is, one of the products in the uranium series is thought to disintegrate in two fashions, one of the products being actinium, the product of the other method of changing being a substance which finally leads to radium.

The accompanying diagrammatic representation of these series of radio-active elements shows the order in which the products occur, their half-decay periods, the rays which they give off in the process of their transmutation, and their maximum valence (Roman numeral).

All of the decay products of the uranium-radium series are found in any geologically old ore containing uranium, the proportionate amount of each product depending upon the rate at which the radio element is undergoing the process of transmutation or decay. For each three million parts of uranium in an old unaltered ore, there is one part of radium. Consequently for each per cent. of uranium oxide (U_3O_8) in a ton of uranium ore, there are 2.5 milligrams of radium element.

Radium of the radio-elements of the uranium-radium series has come to be of more commercial importance than the other members of the series, owing to the fact that it is undergoing the transmutation process rather slowly, requiring 1700 years for the decay of half of any quantity, while the subsequent products, Radium Emanation, Ra A, Ra B and the complex Ra C, are all undergoing a very rapid process of transmutation, resulting in the rapid emission of a succession of rays from each of these products for each atom of radium that transforms. Thus, a radium preparation has the long life of radium, and the high degree of radio-activity contributed by the rapid transmutation of the successive decay products of radium. No other radio-element combines these two advantages in the same degree, the nearest competitor, mesothorium, having a far shorter life than radium, the time required for the transmutation of half of any amount of this element being only 5.5 years.

Pitchblende, the ore from which radium was first produced, occurs in small quantities in several localities in the United States, notably in Gilpin County, Colorado, but so far this ore has not been the source of any radium produced in this country. Carnotite, a potassium uranyl vanadate, is the ore which occurs most extensively in the United States, the most notable deposits being those of southwestern Colorado and southeastern Utah. High-grade carnotite, which is comparatively rare, is a soft, talc-like sulphur-yellow mineral, corresponding essentially to the composition of a potassium uranyl vanadate. The commercial carnotite ore is a low-grade mineral usually found in sandstone formations where the carnotite material acts as a cement for the grains of sand. This low-grade ore contains from traces up to several per cent. of uranium oxide, the workable ore containing from about 0.5 per cent. upward. Owing to the greater amounts of lower-grade ore, the average working ore contains about 1 per cent. of uranium oxide, and consequently each ton of this ore contains 2.5 milligrams of radium element. The great problem of radium production is the economical treatment of these lower-grade ores, which must be conserved because of their more extensive occurrence. The region in which carnotite is mined is remote from railroads, and so the ore must be hauled long distances by burros and wagons. Burros bring the ore from the hills to the wagon roads and the average wagon haul is about forty miles. The ore as found usually consists of a thin layer of sandstone which crops out on the side of a canyon wall and is recognized by the characteristic sulphur-yellow color. The narrowness of the seams makes it necessary to take out a large amount of worthless stone to secure the carnotite ore. The seams are usually in the form of pockets, so that the value of a claim is dubious until it has been thoroly explored and worked.

The physical nature of low-grade carnotite ore is such as to make possible a mechanical concentration of the values. This is carried out on ore containing 2 per cent. or less of uranium oxide. The methods in use are both wet and dry, and consist essentially in a process of grinding to loosen the carnotite material from the sand grains and then separating the values from the tails by a process of dry or wet elutriation.

The fine powdered concentrates are next subjected to chemical treatment to remove the uranium and vanadium, and then the residue, which still contains the radium, is subjected to further chemical treatment to remove this constituent together with the barium salts present in the ore.

Chemically, radium is so nearly like barium as to make it impossible to separate the radium from the barium present in the ore by a single operation. Since a ton of average ore contains only a few milligrams of radium, while the ore usually contains in the order of a half per cent. of barium sulphate or other barium salts, it is obviously simpler to regard the chemical treatment of the ore as a process of removing all the barium from the ore. This is carried out in a number of different ways; some wet, as in the Bureau of Mines nitric acid treatment, which is only applicable to coarsely-ground, high-grade ore, or boiling the concentrates with soda, with subsequent acid leaching; or dry methods, such as fusion with alkali or soda, with subsequent solution of the insoluble radium-barium-calcium residue in acid.

The next step in the preparation of radium salts consists in subjecting the radium-barium salt to a process which will separate the radium from the barium. No strictly chemical process for effecting this separation is suitable, and practically a process of fractional crystallization of the chloride, bromide or hydroxide is used. It was found by Mme. Curie, for example, that radium-barium chloride, when allowed to crystallize from an aqueous solution, gives crystals containing a greater proportion of radium to barium than was contained in the original salt, or the salt left in solution in the mother liquor. Application of this fact in a process of fractional crystallization makes it possible to concentrate the radium in the "heads" and the barium in the "tails," resulting finally after hundreds of operations in the production of a few hundred milligrams of comparatively pure radium salt from the treatment of hundreds of kilos of the crude radium-barium salt as obtained from the ore.

There is probably a total of not more than a hundred and twenty grams of radium element in all the high-grade radium preparations in the whole world. Of this amount thirty grams have been prepared in the Radium Research Laboratory of the Standard Chemical Company during the five years that production has been under way. Other production in the United States, including the radium produced by the United States Bureau of Mines for the National Radium Institute, probably totals about fifteen grams, making the United States the producer, to date, of over a third of the world's radium supply. The present producing capacity of the Standard Chemical Company is 1.5 grams of radium element per month.

The greatest use for radium up to the present has been in the treatment of various growths, malignant and benign. Certain types of cancer respond readily to the action of the beta and gamma rays of radium (the more penetrating rays) and this same action also enables the medical man to give great relief in certain types of hopeless cancer, where medical science has heretofore been helpless. For these medical purposes the radium salt is used, not as a medicine but rather as a physical agent for the production of its characteristic rays. The radium, usually in the form of radium-barium sulphate, containing from 60 per cent. to 90 per cent. of pure radium sulphate, is either sealed hermetically in tiny thin-walled glass tubes or is spread in an enamel or varnish over the surface of a metallic plaque. In this way the radium salt is comparatively safe from loss and may be utilized continually with practically no depreciation, since the activity falls by only one per cent. in about twenty-five years.

A use of radium which has a considerable application, and which now is becoming of almost as great importance as the medical use, is in the production of the so-called permanently luminous compounds. This luminous material finds a wide range of use in all forms of dials and indicators that must be seen in darkness or semi-darkness.

Phosphorescent compounds are those which when exposed to suitable light are capable of storing up some of the energy, which is subsequently emitted in the form of light. A number of phosphorescent substances are known in which the luminescence persists for some time. Of these, the best known was the specially prepared calcium sulphide, which formed the base of Balmain's patented luminous paint. However, exposure to light is absolutely essential to the production of any degree of luminescence, and after such exposure this material emits a bluish light for only several hours. It was first used about 1877 on watch and clock dials, etc., but was practically discarded about twenty years ago, largely because of the necessity of first exposing the articles to light to render the luminous paint effective.

Early in this country, after the discovery of radium and other strongly radio-active substances, such as actinium, it was found that the rays of the radio-active substances were capable of exciting certain materials to the emission of visible light, even when not previously exposed to light—the necessary energy being supplied from the radio-active material. Of all known materials, phosphorescent zinc sulphide, so-called "Sidot's hexagonal blende," gives the greatest luminescence when exposed to the rays of radium, most of the light from the zinc sulphide being due to the numerous scintillations produced by the bombarding of the zinc sulphate crystals by the alpha rays.

Phosphorescent zinc sulphide consists of a specially prepared crystalline form of zinc sulphide which, when mixed with an amount of radium, continues to emit a greenish-yellow light, the intensity of the luminescence being dependent on the quality of the zinc sulphide and the proportion of radium used.

It has been known that many phosphorescent substances respond strongly to the action of ultra-violet rays and X-rays; however, the substances which are very luminescent under the action of these rays (such, for example, as Balmain's calcium sulphide, and native willemite) do not necessarily produce the brightest luminous mixtures when radium is added. To test the suitability of any given material, it is either necessary to add radium directly to the substance and compare the resulting luminosity with that of a good grade of zinc sulphide containing an equivalent amount of radium, or otherwise to bring alpha rays to play on the materials. We have found a polonium plate about twenty millimetres in diameter most useful, since this preparation emits an intense alpha radiation. With a suitable polonium plate a superficial luminescence can be obtained in zinc sulphide equal to that obtained by the addition of several hundred micrograms of radium per gram of zinc sulphide. By holding this plate over two adjacent specimens of zinc sulphide or other material, it is very easy to determine the relative values of their alpha-ray luminescence.

The luminescence of the zinc sulphide is roughly proportional to the radium content, falling off somewhat as increasingly large amounts of radium are added. Commercially luminous compound is in use containing from 25 to 300 micrograms (millionths of a gram) of radium element per gram of the mixture. Careful photometric tests have demonstrated that the rate of decay of the luminescence is proportional to the amount of radium, so that compounds which initially are brightest show the most rapid falling off in luminescence, while compounds containing proportionally less radium are not initially so brilliant, but have a longer effective life.

The decay in the luminescence of compounds in which radium is the exciting agent is not due to change in the radio-active substances, since it is well known that radium changes so slowly as to require 1700 years for its half-decay—approximately 1/25th of one per cent. change taking place in one year. The change in the zinc sulphide, however, is not so slow, which accounts for the diminishing luminescence of the compound with time. There are many points in connection with light emission from zinc sulphide that still remain to be explained. However, it may be said that the behavior of the substance indicates a capacity for sending out only a certain total amount of light, so that where a greater luminosity is excited by the use of a larger proportion of radium, the life of the zinc sulphide is proportionately shortened.

In the application of the luminous compound for its various uses it is mixed with a suitable vehicle, usually some form of clear, transparent varnish, the resulting thick paint being applied by means of a fine stiff-haired brush or a fine stylus. The difficulties to be overcome in this connection are dependent on the nature of the material and surface to be painted, as well as the nature of the surroundings. Paper, porcelain, mica, and metal dials of all sorts bearing figures and lines are now used. In the liquid-damped compasses, such as the aero-compasses, the card floats in alcohol, thus introducing a further requirement that the luminous paint resist the action of this solvent. The varnish most suitable for this purpose is yet to be found. For some instruments, such as aeroplane instruments, the requirements of luminosity are of most importance and outweigh the other considerations of cost and length of effective life. For such purposes the grades of luminous compound are prepared which give the highest initial luminosity, due to a larger proportion of radium, and having, consequently, a shorter effective life. For many other purposes, such as the use on marching compasses, wrist watches, etc., luminous compound of lower initial luminosity is recommended, and this material has the advantage of lower cost and longer life.

The chemistry of the radio-elements and the work on the constitution of the atom (a large number of the most important articles on this subject have appeared in the Philadelphia Magazine during the past several years. The article by Rutherford on " The Structure of the Atom " in vol. 27, p. 488, March, 1914, is very interesting for the general reader) which has grown out of the study of the radio-elements and their rays presents a far more interesting field than the technology of radium, particularly since the various phases of the treatment of radium ore, etc., cannot be detailed minutely. The atom, according to J. J. Thompson, can be considered as a series of concentric rings of electrons in rapid orbital motion about or within a sphere of positive electrification. Such an atom is capable of accounting for many of the properties of matter, both material and electrical. Rutherford more recently has modified this view of the atom and considers the sphere of positive electrification or nucleus of the atom as exceedingly minute in comparison with the dimensions of the atom. This view is the result of careful observations on the scattering or deviation of alpha rays from their paths in passing thru matter, the assumption being that the very sharp bends in the path of the alpha ray indicate an approach of the alpha ray to the nucleus, causing the deviation. Mathematical calculations by Darwin for alpha rays in hydrogen demonstrate that the centres of the nuclei (the alpha ray is the nucleus of the helium atom) must approach to within 1.7×10^{-13} centimetres of each other. This view is confirmed also by experiments made by Marsden on the repulsion of the hydrogen nuclei by alpha rays. According to Rutherford, the hydrogen atom consists of one negative electron moving orbitally about the nucleus, which consists of a positive electron having a much smaller diameter than the negative electron. As is well known, the mass of the negative electron is about 1/1700 the mass of the hydrogen atom, so that the bulk of the mass of the hydrogen atom must reside in the nucleus, and this is accounted for on the basis of electro-magnetic mass by the fact that the diameter of the hydrogen nucleus is so much smaller than that of the negative electron. Alpha rays penetrating into a gas, such as hydrogen, move thru a definite distance before they lose their kinetic energy and become ordinary helium atoms. This distance is called their range, and within its range the alpha ray is capable of producing such phenomena as ionization of gases, scintillation in zinc sulphide, etc., whereas at a distance greater than the range, these phenomena are not observed. Marsden has found that when the alpha rays from radium impinge into hydrogen gas there are the usual scintillations observed on a zinc sulphide screen due to the alpha rays; however, beyond the range of the alpha rays, some three or four times the distance to which the alpha rays could penetrate, there are still scintillations and these are attributed to the hydrogen nuclei which are set in rapid motion by collision with the alpha rays, the energy of the alpha ray being transferred to the hydrogen nucleus, and this having a smaller mass moves thru the longer range.

The nature of the X-rays and the gamma rays was the subject of considerable discussion for many years, altho the majority inclined to the opinion that these rays were of the nature of ether pulses. Owing to the fact that the rays could not be defracted or reflected it was not possible to demonstrate satisfactorily their relation to ordinary light. Visible light, as we know, can be defracted by means of a grating made by ruling parallel lines on a suitable plate, using many thousands of lines per inch. It occurred to Laue, a German physicist, that the orderly arrangement of the atoms in a crystal might serve as a grating for the defraction of the X-rays, and at his request Friedrich and Knipping observed the effect of passing a thin beam of parallel

X-rays thru a crystal of copper sulphate to a photographic plate. The result was a dark central spot on the photographic plate corresponding to the direct beam of rays and about this central spot were symmetrically arranged lighter spots corresponding to defracted beams. This marked the beginning of a careful study of the nature of X-rays and the closely related gamma rays. Suffice to say that it seems evident from the work of Moseley, de Broglie, the Braggs, and Rutherford and his students, that all of the elements are characterized by a definite X-ray spectrum. Just as we know, that the different elements have characteristic lines in the visible spectrum, so it has been found that there can be excited by the elements definite vibration of short wave-length which we call X-rays, and a simple relation has been observed between the frequency of these X-ray vibrations of the elements and the elements when they are set in the order of their increasing atomic weight. A general formula has been developed relating the frequency of the characteristic X-rays and certain constants with a variable which is an integer, the particular integer for each element being called the atomic number. By arranging the elements in order of increasing atomic weight it has been found that the successive atomic numbers may be represented by the integers, beginning with H as unity. This most interesting result for the first time gives us a relation between various elements which does not involve the fractions that are so puzzling in connection with atomic weights, if we could consider the atoms as being built up from a few fundamental units such as electrons and hydrogen nuclei.

Viewed in the light of the Rutherford atom we must assume that the heavier atoms consist of a small nucleus, about which are rotating rings of negative electrons. The mass of the atom depends mainly upon the nucleus, whereas the chemical properties and the visible spectrum depend upon the number and arrangement of the outer electrons. The number of these outer electrons is of the order of one-half the atomic weight, and corresponds to the number of unit positive charges on the nucleus, which in turn corresponds to the characteristic atomic number. The important generalization growing out of this is that the nucleus charge, rather than the atomic weight, is the determining factor governing the chemical and certain physical properties of the elements. The statement of the periodic law must be modified and we may say that the chemical properties of the elements, and those physical properties not dependent on the mass of the atom, are a periodic function of the nucleus charge (atomic number); for, as we shall see, there are elements having practically identical atomic weights (uranium X_1 and uranium X_2) with differing chemical properties, and other elements having measurably different atomic weights (radium G and lead) with identical chemical properties and spectra. If this is the case, then in the uranium atom which has an atomic number of 92, there will be 92 negative electrons moving in orbits about the nucleus. The nucleus is made up of negative electrons and positive electrons. There are good reasons for believing that the alpha and beta rays emitted by radio-active atoms come from the nucleus of the disintegrating atom. It is significant that the helium nucleus rather than the hydrogen nucleus is thrown off, and this would seem to point to a large number of helium nuclei being present in the make-up of the radio-active atom. The helium nucleus we may assume to be made up of four hydrogen nuclei with two negative electrons. It is possible there is a variety of stable configurations similar to the helium nucleus which go together to form the nucleus in the heavier atoms. As far as radio-active evidence shows us, only helium nuclei and negative electrons are emitted in the process of radio-active transmutation; therefore, we may assume, for example, that the nucleus of the uranium atom consists of 59 helium nuclei and 2 hydrogen nuclei and 28 negative electrons, since the atomic weight (238) must be accounted for mainly by the mass of these particles. In the process of transmutation one helium nucleus is lost from the uranium nucleus and the resulting atom is uranium X_1.

An interesting rule has been given by Soddy to account for the valence changes in the successive radio-elements. Loss of an alpha particle lowers the valence of the succeeding element by 2, whereas the loss of a beta particle increases the valence by 1. A reference to the table of the radio-elements, given before, shows how well the observed results accord with these rules. Uranium 1 with the valence 6 emits an alpha ray and uranium X_1 corresponds in its chemical properties to an atom of valence 4. Uranium X_1 emits a beta particle and uranium X_2 has the valence 5. Uranium X_2 loses a beta ray and uranium II has the valence 6.

This brings up the interesting point of the placing of the radio-elements in the periodic system. The placing of the element in the periodic system signifies that we attribute to the element certain chemical properties. Ordinarily between two closely related elements there are a number of dissimilar elements, so, for example, in passing from sodium to potassium we find magnesium, aluminium, silicon, phosphorus, sulphur, chlorine and argon. In the case of the radio-elements we find practically thirty elements between the atomic weight 206 and 238, so that it is obviously impossible to place each of the elements in a separate place in the periodic table, there being only room for about fifteen elements at most. It was early observed that certain of the radio-elements seemed to be inseparable from each other by the ordinary chemical or physical methods used; for example, a preparation of thorium which should have contained several per cent. of ionium was found to have only the spectrum of thorium, and it was impossible to separate the thorium from the ionium present. Likewise, thorium and radio-thorium were found to be inseparable, as were also radium and mesothorium 1. This chemical similarity was at first thought to be comparable to that of the rare earths which have required the most careful work to achieve their separation. Soddy, however, has advanced an hypothesis to account for this chemical similarity which, from the standpoint of importance to chemistry, ranks second only to the generalization of Rutherford and Soddy in regard to the transmutation of the radio-elements. Briefly, this view is that we may have elements of different atomic weight but of identical chemical properties. In the case considered above, uranium I and uranium II differ by about 4 units (1 helium nucleus and 2 electrons) in their atomic weights, but both have the same valence, and it has been found that the two forms of uranium, which were long suspected because of the two alpha rays of different range emitted from uranium, cannot be separated by any known methods. Hence these two elements are grouped together in the one space of the periodic table, and Soddy has suggested for this and similar elements the name isotopes, meaning that they occupy the same position. With this in view and with the rules above referred to, we may readily place all of the radio-elements in the few positions of the periodic table that are available. For example, ionium results from uranium X_2 by the loss of an alpha particle. Ionium is quadrivalent. Radium results from ionium by the loss of an alpha particle. Radium is bivalent, belonging in the group of the alkaline earths. Radium emanation results from radium by the loss of an alpha particle and this gas belongs to that group of noble gases characterized by zero valence. We must bear in mind that the periodic table is best represented by a spiral arrangement of the elements passing from one group up to the next group, so it is not surprising that radium emanation by the loss of an alpha ray produces radium A with a valence of 6, this element finding its position in the next lower group of the periodic table. Radium A by the loss of an alpha ray produces radium B, which is quadrivalent, and so on until finally radium F by the loss of an alpha ray produces the element radium G, which there is reason to believe does not undergo any further disintegration. Radium G, by the reasoning above mentioned, should have a valence of 4, and if we subtract 4 for each alpha ray lost, the atomic weight should correspond to about 206. Lead has an atomic weight of 207.15 according to the most accurate determinations, and a maximum valence of 4. For a number of years it was considered that the final product from uranium was lead; however, the difference in the atomic weights was not clearly to be explained. On the basis of this theory of isotopes it becomes very important to determine whether lead occurring in radio-active minerals and presumably due to the atomic disintegration of uranium has the same atomic weight as the lead occurring in ordinary non-radio-active minerals. Of this work we may cite the determinations of Richards and Lembert at Harvard, who found an actual difference in atomic weight between ordinary lead and lead from the uranium minerals, their lowest figure for the radio-active lead being about 206.4. The spectrum and the atomic properties of radium G correspond in every respect to those of ordinary lead, and experiments have shown that these elements can replace each other in the electrodes of concentration cells, showing again the identity of properties of the isotopic elements. In fact, radium B, radium D, and radium G are all chemically identical to ordinary lead.

From the standpoint of the structure of the atom the isotopic elements must be considered as having the same number of electrons in the outer rings, thus conferring similarity of spectra, valence and chemical properties, whereas the difference in the atomic weight is accounted for by the difference in the constitution of the nuclei of the atoms.

The work of Rutherford and Andrade on the characteristic X-ray spectrum of lead and the gamma-ray spectrum of radium B, which is isotopic with lead, is of great interest, since their results point conclusively to the fact that the characteristic X-ray spectrum of lead is the same as the characteristic gamma-ray spectrum of radium B.

The views above mentioned in regard to the nature of the atom and the work on the atomic numbers of the atoms still rest on more or less roughly determined physical data, so that it is possible that more refined measurement will necessitate certain changes in the views, but the work so far goes to corroborate the hypothesis of isotopes and we may safely say that this generalization is one which will not be altered. We have in the group of radio-elements the remarkable condition of the atomic weight not being the important factor in determining the exact chemical nature of the atom, since elements such as uranium X_1 and uranium X_2, which are known to differ by only the mass of an electron, have different chemical natures. On the other hand, as an example, we find radium B, D, G and lead all have different atomic weights with absolute identity of chemical properties. These views are not less striking when compared with the views in regard to the chemical properties of the atoms in the early 90's than are our present views with regard to the transmutation of matter when compared with the views on the same subject several decades ago, and it is the writer's opinion that in these two important generalizations are summed up the most important results of the study of radio-activity from the standpoint of chemistry.

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SECRETARY'S NOTICES

ABSTRACT OF MINUTES OF REGULAR MEETING OF THE BOARD OF DIRECTORS

JUNE 11, 1918

The meeting was called to order at 7.15 P.M. by Treasurer Stevens, with Directors Fernald, Henderson, Gant, J. C. Wagner, Kenney, Douglas, Past Presidents Swaab and Carter and Secretary Stockly in attendance. President Vogleson, Vice Presidents Yarnall, Andrews and Eglin, Directors Hayward, Moody, S. T. Wagner, Forstall, Terrell, G. W. Barr, R. M. Barr and Past President Ledoux were excused. Director Ehle was absent.

The minutes of the Regular Meeting of May 14, as issued to the members of the Board, were approved.

REPORT OF THE PRESIDENT

Mr. Joseph C. Wagner, who, in accordance with authority granted at the May 14 meeting, was appointed delegate to represent the Club at the City Planning Conference held in St. Louis, May 27 to 29, presented a report of the Conference, which was accepted and ordered to be published in the Club JOURNAL.

REPORT OF THE SECRETARY

The report of the Convention of the American Society of Engineers, held at the City Club, Chicago, Illinois, May 14, 1918, received from Mr. H. E. Hilts, who was appointed delegate of the Club to attend the Convention, was presented and accepted.

Announcement was made of the death, on April 28, 1918, of Mr. Frank Shuman, Active Member of the Club since November 17, 1914.

Announcement was made that to date, 135 members in service have applied for remission of dues.

Resignations from the following members in good standing were presented and accepted as of March 31, 1919:

C. E. Drehmann
E. S. Foljambe
A. R. Glancy
Howard A. Loeb
M. P. Quinn

REPORT OF THE COMMITTEE ON HOUSE

The Secretary reported that a complete revision of the House Rules was in progress, and would be ready for presentation at the next Board meeting.

REPORT OF THE COMMITTEE ON MEMBERSHIP

On the recommendation of the Committee the following were elected:

To *Active* Membership:

Clarence E. Davies
Guy S. Elmore
Harry A. Hornor
Gilbert C. Lamb
Richard V. Mattison
George H. Morgan
Charles A. Schranz
Donald B. Spanogle
George A. White
Edward Woodbury
William Wilcox

To *Junior* Membership:

Howard F. Collins
Kenneth W. Heinrich
Adam G. Hilton
LeRoy Hilyard
Benjamin A. Skinner

The meeting adjourned at 8.15 P.M.

H. A. STOCKLY,
Secretary.

OF SPECIAL INTEREST!

BEGINNING WITH TUESDAY, JULY 16, A REGULAR CLUB FEATURE WILL BE A

"TUESDAY ADDRESS LUNCHEON"

FROM 12.30 TO 1.30 P. M., AT WHICH TIME WELL-KNOWN SPEAKERS WILL ADDRESS THE CLUB ON UP-TO-THE-MINUTE SUBJECTS.

COMMITTEE ON MEMBERSHIP

PAUL SPENCER, Chairman

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before July 6 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

ROBERT H. ANDERSON

800 Mattison Avenue, Ambler, Pa.

Vice President and Superintendent of Keasbey and Mattison Company.
Proposed by Charles E. Bonine and H. F. Sanville.

LEONARD C. BUTLER

415 North Wayne Avenue, Wayne, Pa.

Manager, Telautograph Corporation.
Proposed by H. F. Sanville and Kern Dodge.

CLARENCE E. DAVIES

1013 West Lehigh Avenue, Philadelphia, Pa.

Assistant to Superintendent of Production of the Artillery, Ammunition Division, Frankford Arsenal.
Proposed by Lewis F. Moody and John P. Mudd.

FRANCIS W. DEAN

Philadelphia, Pa.

Emergency Fleet Corporation, 140 N. Broad Street,
With Emergency Fleet Corporation.
Proposed by John Overn, Jr., and Lewis F. Moody.

J. PRICE EWING

The Baldwin Locomotive Works, 500 North Broad Street, Philadelphia, Pa.

Mechanical Engineer—In charge Electric Locomotive Design, Baldwin Locomotive Works.
Proposed by Jacob Y. McConnell and Harry Glaenzer.

JONATHAN CHARLES HINTON

1600 Hamilton Street, Philadelphia, Pa.

Office Manager, Transmission Dept., Wm. Sellers & Co.
Proposed by Edw. J. Baechle and Coleman Sellers, Jr.

W. M. MARKS

Care of Western Electric Company, Inc., Eleventh and York Streets, Philadelphia, Pa.

Sales Engineer, Western Electric Company, Inc.
Proposed by H. P. Gant and Herbert Rader.

JAMES HURON WOOD

1036 Commercial Trust Building, Philadelphia, Pa.

President of the Eastern Machinery and Equipment Company.
Proposed by Amos P. Fisk and W. R. McLain.

FOR ELECTION TO JUNIOR MEMBERSHIP

DONALD STEWART KNIGHT

602 North Twenty-second Street, Philadelphia, Pa.

Draftsman, E. V. d'Invilliers, 518 Walnut Street, Philadelphia, Pa.
Proposed by J. B. Dilworth, Walter Gilman and Benjamin Franklin.

POSITION OPEN

Leather belting house wants power and transmission man. Must be able to figure belting drives and should have technical training backed up by practical experience. Apply 216-a, Engineers' Club.

POSITION WANTED

Position wanted as foreman of construction. Can handle men. Have had about ten years' experience as draftsman. Good right-hand man for a mechanical engineer. Apply 212, Engineers' Club.

FOR SALE

Complete set of the Proceedings of the Engineers' Club of Philadelphia. Apply 5-B, Engineers' Club.

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, CHAIRMAN

"From these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion; these dead shall not have died in vain."—ABRAHAM LINCOLN.

BARKER, EDWARD WILLIAMS, Sergeant ....Junior Member..........Died March 17, 1918, Camp Meade, Admiral, Md.

LIEUTENANT HARRY W. PRINCE

LIEUTENANT HARRY WALTER PRINCE, aviator, was killed while making a practice flight in England, on June 11. He was the son of Mr. and Mrs. John Prince, Fifty-fifth Street and Springfield Avenue. Lieutenant Prince was twenty-five years old. He entered the aviation service in October, 1917, was sent to the ground school first at Columbus, O., and then to Camp Hicks, Texas. Later he was transferred to Garden City, L. I. He sailed from an American port about seven weeks ago, and his training was to have been completed in an English camp.

Lieutenant Prince was born in Bryn Mawr. He attended the public schools, and was graduated from the Central Manual Training School in 1911. At the time of his enlistment he was a civil engineer with the Birkinbine Engineering Company, and a Junior Member of the Engineers' Club.

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF JUNE 25, 1918

NAME	RANK	CORPS	LOCATION
ALDRICH, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
ALLEN, H. BUTLER	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, via New York
ALLEN, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
ANDERS, D. W.	Major	Company D, 502nd Engineers	American Expeditionary Forces, France
ANDREWS, J. H. M.	Major	Ordnance R. C.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
ASPLUNDTH, E. T.	Captain	103rd Engineers	American Expeditionary Forces, via New York
ATTERBURY, W. W.	Brigadier-General	Director-General of Railways	France
BAKER, W. D.	2nd Lieutenant	Aviation Corps	France
BANISTER, E. S.	Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
BARNES, H. P.		Naval Flying Corps Mass. Inst. Technology	Cambridge, Mass.
BARNES, F. B.	Master Engineer	Headquarters Department 26th Engineers	American Expeditionary Forces, via New York
BASSETT, F. H., JR.		Officers' Training School	Camp Meade, Md.
BEAR, H. K.	Lieutenant	Gas Defense Service	Camp Greenleaf, Ft. Oglethorpe, Ga.
BEATTY, L. B.	Ensign	U. S. Naval Reserve Force	705 Parker Ave., Collingdale, Pa.
BELL, FRANK F.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
BESCHERER, P.	2nd Lieutenant	319th Heavy Artillery	Camp Gordon, Ga.
BETUS, A. J.	Major		A. P. O. 720, American Expeditionary Forces, via New York
BIESTER, W. H., JR.	Corporal	"Co. E," 103rd Engineers	American Expeditionary Forces, via New York
BISHOP, A. B.			Post Field, Fort Sill, Oklahoma
BOOZ, H. C.	Colonel	In Charge of Construction of Railroads, Wharves. etc.	Amer. Exped. Forces, via New York
BORDEN, J. M.	2nd Lieutenant	Ordnance Reserve Corps	Hudson Motor Car Co., Detroit, Mich.
BORRESEN, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
BOYD, F. F.	Lieutenant Engineer Officer	U. S. Naval Reserve Force	Submarine Base, New London, Conn.
BOYD, G.	1st Sergeant	Gas Service	A. P. O. 717, American Expeditionary Forces, via New York
BRADFORD, J. S.	Major	103rd Engineers	Camp Hancock, Augusta, Ga
BRADT, MORRIS	1st Lieutenant	Ordnance Officers' Reserve Corps	Hqrs. Base Section No. 3, Line of Communication, A. E. F., Goring Hotel, Grosvenor Gardens, London, S. W. 1

Bransome, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
Bream, C. C.	Corporal	103rd Engineers	American Expeditionary Forces, via New York
Breen, J. W.	Captain	Gas Service, Engineer Officers' Reserve Corps	Amer. Exped. Forces, via New York
Brewer, P. C., Jr.	2nd Lieutenant	307th Engineers	Camp Gordon, Atlanta, Ga.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Britten, D. L.	Captain	Ordnance Officers' Reserve Corps	Inspector of Ordnance, Haddon Apts., Cleveland, O.
Broadhead, Alex		19th Reserve Engineers	American Expeditionary Forces, via New York
Brogan, C. M.		Quartermaster's Corps, Utility Detachment, Barracks "B"	Camp Meade, Admiral, Md.
Brown, J. A.	Major	Ordnance Officers' Reserve Corps	Smithtown, L. I., New York
Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier-General W. W. Atterbury
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, via New York
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. F.	1st Lieutenant	520th Co., N. A.	Fort Myer, Va.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	1st Lieutenant	103rd Engineers	American Expeditionary Forces, via New York
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.	1st Lieutenant	Ordnance Reserve Corps	Washington, D. C.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Chance, T. M.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Childs, H. P.	1st Lieutenant	23rd Engineers	American Expeditionary Forces, France
Clark, J. W.		Russian Railway Service	Nagasaki, Japan
Cleeland, R.	Cadet Engineer	S. S. Neuse	Care U. S. Shipping Board
Colgan, R. J.	Captain	11th Regiment Engineers	Care of Adjutant-Gen'l, Washington, D. C.
Craig, Coulter	Captain	Ordnance Officers' Reserve Corps Supply Division	Office, Chief of Ordnance Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	American Expeditionary Forces, via New York
Crowther, E. C.	1st Sergeant	Base Hospital No. 38	Second Regiment, N. G. P., Armory, Philadelphia
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Chamber of Commerce Bldg., Pittsburgh, Pa.
Cutler, James B.	2nd Lieutenant	319th F. A. R. C.	Camp Gordon, Ga.
Darlington, I. G.	1st Lieutenant	Gun Section, Production Division	Washington, D. C.
Davies, C. E.	Lieutenant	Ordnance Department, U. S. A.	Frankford Arsenal, Philadelphia
Day, R. F.	2nd Lieutenant	Aviation Corps	3rd Squadron, Ellington Flying Field, Houston, Texas
Derby, C. F.	Captain	Ordnance Officers' Reserve Corps	Camp Lee, Petersburg, Va.
Dill, C. M.	Lieutenant	Headquarters Co., 10th Ba., F. A. R. D.	Camp Jackson, S. C.
Donnelly, J. B.	1st Lieutenant	103rd Engineers	American Expeditionary Forces, via New York
Doyle, T. H.	2nd Lieutenant	U. S. Quartermaster's Corps	Overseas Service
Dunlap, V. R.	Lieutenant (Jr.)	Ass't Civil Engineer, U. S. N.	Naval Air Station, Pensacola, Fla.
Dunn, M. L.	Ensign	"U. S. S. Connecticut"	Care Postmaster, N. Y.
*Dyson, C. W.	Rear Admiral	Bureau of Steam Engineering, U. S. N.	Washington, D. C.
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.
Elcock, Chas.	Captain	103rd Engineers	American Expeditionary Forces, via New York
Farr, Roy S.	2nd Lieutenant	Engineers' Reserve Corps	A. P. O. 713, American Exp'y Forces, via New York
Faust, W. D.		103rd Engineers	American Expeditionary Forces, via New York
Fenton, Powell		Aviation Corps	France
Ferree, D. S.	Engineer Officer	Aviation Section, Signal Corps	M. I. T. School of Military Aeronautics, Cambridge, Mass.
Filbert, C. B.	Captain	41st Engineers	American Expeditionary Forces, France
Fish, W. N.	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Maryland
Forster, A. O.	Captain	Army Supply Base	59th St. and 1st Ave., So. Brooklyn, N. Y.
Frank, A.	Corporal	1st Replacement Regiment Engineers—Co. "A"	Fort Foote, Maryland
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	P. O. 717, American Expeditionary Forces, France
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gauthier, Jordan	2nd Lieutenant	4th Platoon, Co. "C," 56th Engineers	Zone of the Advance, American Expeditionary Forces, via New York
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Getz, Ralph F.	2nd Lieutenant	32nd Engineers	Camp Grant, Ill.
Gilbert, W. T.		21st Railway Engineers	American Expeditionary Forces via New York
Gillam, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Goldsmith, H. F.		Naval Aviation Training School	Cambridge, Mass.
Goodwin, H., Jr.	Lieutenant	U. S. Naval Reserve Force	Bureau of Naval Officers' Operations, 1728 G St., N. W., Washington, D. C.
Gracey, A. L.	Private	Advance Ordnance Depot No. 4	American Expeditionary Forces, via New York

Graham, W. R.	1st Lieutenant	Aviation Section Signal Officers' Reserve	Aviation Mob. Camp, Camp Sevier, Greenville
Gravell, W. H.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Gray, B. D.	Major	Signal Corps, U. S. A.	Adams Bldg., Washington, D. C.
Gribbel, W. G.	Captain	30th Engineers, Gas & Flame Division	American Expeditionary Forces, via New York
*Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C
Grossman, P. R.	Private	G. H. Q. Amer. Expeditionary Forces	U. S. M. P. O. No. 706, France
Gwilliam, Mark R. M.	Captain	21st U. S. Infantry	San Diego, Calif.
Hall, W. A.	Lieutenant	U. S. Navy, In Eurapean Waters	Base 17, Care of Postmaster, N. Y. C.
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	Co. "F," 32nd Engineers	Camp Grant, Rockford, Illinois
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hart, R. P., 2nd	Lieutenant	44th Engineers	Ft. Benjamin Harrison, Ind.
Hathaway, H. K.	Lieut.-Colonel	Ordnance N. A.	Washington, D. C.
Havens, C. R.		Meteorological Squadron, U. S. Signal Corps	A. & M. College, College Station, Texas
Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
Heger, J.	Lieutenant	Engineers' Depot	Washington, D. C.
Henderson, S. D.	Private	304th Engineers	Camp Meade, Admiral, Md.
Henry, J. C.		Headquarters Dep't 19th Reserve Engineers	Amer. Exp. Forces, via New York
Hetherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Hqrs. 1st Bn., 61st Infantry	A. P. O. 728, American Exp'y Forces, via New York
Hollenback, E. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.	1st Lieutenant	Dental Corps, 28th Division	American Expeditionary Forces, via New York
Houwen, W. P.	C. M. A. A.	United States Navy Air Station	Cape May, N. J.
Hulme, Norman	1st Lieutenant	458th Truck Co.	Fort Myer, Va.
Hunter, N. R.	2nd Lieutenant	47th Engineers	Camp Sheridan, Ala.
Hutchison, G. B.		Elec. School, Naval Operating Base	Hampton Road, Va.
Hyland, G. N.	2nd Lieutenant	Aviation Concentration Camp	Camp Dick, Dallas, Texas
Jaques, J. D.	Lieutenant	U. S. N. R. F., Public Works Dept.	Navy Yard, Boston, Mass.
John, R. R.		Officers' Training School for Coast Artillery	Fortress Monroe, Va.
Jones, Jonathan	Captain	23rd Regiment Engineers	American Expeditionary Forces, via New York
Kennedy, J. H.	Cadet	8th Aviation Instruction Centre	American Expeditionary Forces, via New York
Kent, S. L., Jr.	1st Lieutenant	34th Engineers	Camp Dix, N. J.
Kern, F. X.	Lieutenant	23rd Regiment Engineers	American Expeditionary Forces, via New York
Klein, A. C.	Lieutenant	Production Section, Gun Division	Office, Chief of Ordnance, Washington, D. C.
Kneass, E.	Ensign	U. S. Submarine Base	New London, Conn.
Knight, C. C., Jr.	Lieutenant	318th Field Artillery, N. A.	Camp Jackson, S. C.
Koelle, W. F. B.	Sergeant	Signal Corps	Washington, D. C.
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	Amer. Exp. Forces, via New York
Laverty, C. R.		Co. "F," 305th Engineers	Camp Lee, Va.
Lawrence, G. E.	Lieutenant J. G.	U. S. Naval Res. Force	U. S. S. "Nokomis," European Waters, care Postmaster, N. Y.
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Lees, E. A.	1st Lieutenant	Company "E," 56th Infantry	Camp MacArthur, Waco, Texas
Levin, J.	2nd Lieutenant	Coast Artillery Reserve Corps	Fort Hancock, N. J.
Loeb, A. H.		154th Depot Brigade 1st Detachment	Camp Meade, Admiral, Md.
Lynch, N. H.		"F" Co., 6th U. S. Engineers	American Expeditionary Forces, France
MacGarrigle, G. L.	Private	Company "B," 103rd Engineers	American Expeditionary Forces, via New York
Maclean, M. R.	Major	Headquarters 5th Bn., 154th Depot Brigade	Camp Meade, Md.
Magee, J. W.	1st Lieutenant	446th Engineers' Pontoon Train	Washington Barracks, D. C.
Mahan, J. H.		U. S. Signal Corps Radio School	Columbia University, New York City
Mallon, G. J.	Lieutenant (Jr.)	U. S. Naval Reserve Force	U. S. S. "Mt. Vernon," care of Postmaster, N. Y.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Mann, C. P.	1st Lieutenant	Coast Artillery Reserve Corps	Berverly, N. J.
Mardaga, L.	Ensign	U. S. Naval Reserve Force	Asst. Naval Inspector of Ordnance, Alloy Steel Forging Plant, Carnegie, Pa.
Martin, T. S., 3rd	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Mayburry, W. G., Jr.	Lieutenant	334th Field Artillery, National Army	Camp Pike, Ark.
McCausland, J. R.	Master Engineer Senior Grade		U. S. Post Office 701, R. T. O., American Expeditionary Forces, France
McClintock, J. L.		U. S. Navy Radio Station	Atlantic City, N. J.
McCord, J. B.	Lieutenant-Colonel	Ordnance N. A.	American Expeditionary Forces, France
McCormick, J. C.	1st Lieutenant	Co. "C," 1st Engineers	American Expeditionary Forces, via New York
McCoy, J. F.	2nd Lieutenant	Aviation Section, Signal Corps	
McGarrigle, J. J.	1st Lieutenant	Anti-Aircraft, Artillery C. A. C.	American Expeditionary Forces, France
McMillan, H. L.	Major	Engineer Officers' Reserve Corps	Camp Humphrey, Va.
Millar, E. A., Jr.	1st Lieutenant	Ordnance Officers' Reserve	Camp Hancock, Augusta, Ga.
Mohr, C. F.	Private	Co. "B," 45th Engineers	Camp Humphrey, Va.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.

Moon, T. E.	Corporal	119th Ordnance Depot Co.	Camp Hancock, Augusta, Ga
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Murphy, H. C.	Ensign	U. S. Navy	Bureau of Ordnance, Navy Dep't, Washington, D. C.
Meyers, W. C.	Captain	Ordnance Officers' Reserve	Inspection Division Standard Steel Car Co. Butler, Pa.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	1st Lieutenant	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixon-Miller, M.	Captain	Commd'g Company "B," 501st Engineers	American Expeditionary Forces, via New York
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
***Oakes, J. C.**	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Orr, M. W.		First Battery, Officers' Training School	Camp Meade, Md.
***Otwell, Curtis W.**	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Perry, Edward	Sergeant	Motor Truck Company No. 329	Camp Lee, Petersburg, Va.
Peterman, J. M.	2nd Lieutenant	5th Bn., 152nd Depot Brigade	Camp Upton, N. Y.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pierce, D. T.		American Red Cross	France
Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Prichett, F. B.		103rd Trench Mortar Battery	American Expeditionary Forces, via New York
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	79th Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	Hqrs. 19th Reserve Engineers, Railway	Amer. Exp. Forces, via New York
Reed, Thomas	Captain	Ordnance Officers' Reserve Corp	Inspector of Ordnance. Walter Scott & Company, Plainfield, N. J.
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Reninger, H. A.	Major	Headquarters, 103rd Ammunition Train, 28th Div.	Amer. Exp. Forces, via New York
Ridge, R. S.	Sergeant	Co. "A," 23rd Engineers	American Expeditionary Forces, via New York
Ridgway, J. J.	1st Lieutenant	Co. "F," 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.	Private	201st Aero Squadron	American Expeditionary Forces, via New York
Rogers, J. I.	Lieutenant	United States Naval Reserve Force	U. S. S. Helenita, in care of Postmaster, Fortress Monroe, Va,
Roop, J. C.	Captain	17th Engineers	American Expeditionary Forces, via New York
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Russell, J. A.	Lieutenant	311th Engineers	Camp Grant, Rockford, Ill.
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Satterwhite, R. L., Jr.		Company 20, Naval Aviation Detachment	Massachusetts School of Technology Cambridge, Mass.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	New York Arsenal, Governor's Island, N. Y. Harbor
Schaum, O. W.	Aeronautical Mechanical Engineer	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
Schoch, J. B.	Lieutenant	109th U. S. Infantry	Camp Hancock, Augusta, Ga.
Schoff, A. L.	1st Lieutenant	Signal Corps, Land Division	Fort Worth, Texas
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defense Service, Med. Dept., U. S. A.	Washington, D. C.
Scull, M. A. H.	Lieutenant	Railroad Transportation Corps	U. S. A. P. O. 717, American Exp'y Forces, via New York
Shallcross, J. B.	Lieutenant	Ordnance Reserve Corps	Inspection Div., 6th & B Sts., N. W., Washington, D. C.
Sheahan, J. C.	2nd Lieutenant	Co. 11, Section B, Bldg. 6	Camp Jos. E. Johnston, Jacksonville, Fla.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Smith, A. H.	Sergeant	Utilities Detachment Quartermaster's Corps	Barracks B 104, Camp Meade, Admiral, Md.
***Smith, W. S.**	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	A. P. O. 702, American Exp'y Forces, via New York
Spillan, J. J. D.	2nd Lieutenant	103rd Trench Mortar Battery,	American Expeditionary Forces, via New York
St. John, Everett	1st Lieutenant	Coast Artillery Reserve Corps	Port duPont, Delaware
***Tawresey, J. G.**	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	Major	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Engineer Officers' Training Camp	
Thacher, C. H.	2nd Lieutenant	Engineer Officers' Training Camp	Belvoir, Va.
***Thomas, R. S.**	Colonel	22nd Engineers	Camp Sheridan, Montgomery, Ala.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Corporal	Ordnance Detachment "B"	Gunpowder Reservation, Edgewood, Md.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Maine"
Truhan, L. J.		Reserve Officers' Barracks "B," Room No. 373	Naval Academy, Annapolis, Md.
Uhler, W. D.	Major	Quartermaster Corps, N. A.	Washington, D. C.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal
Vaughan, D. L.	Captain	Quartermaster's Corps N. A.	Camp Logan, Houston, Texas
Voegelin, E.		10th Company	Barracks, Columbus, Ohio

Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Hqr's, 34th Artillery Brigade	Fort Adams, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces via New York
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	R. R. & C., S. O. S.	American Expeditionary Forces, via New York
Webster, E. L.		Reconstruction Relief Work Friends' Unit of the Red Cross	France
Wentz, E. M.	Asst. Paymaster	U. S. Naval Reserve Force	U. S. S. Topila, care of Postmaster, N. Y. C.
Wheeler, G. C.	Private	Base Hospital No. 18	American Expeditionary Forces, via New York
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	American Expeditionary Forces, via New York
White, J. A. Jr.	Private	Co. "A" 109th Infantry	Camp Hancock, Augusta, Ga.
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Wilkinson, R. W.		Engineers' Training School	Carnegie Institute, New York
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	Office of Inspector of Ordnance, U. S. A. Highland Park, Michigan
Wood, E. R. Jr.	Captain	18th Field Artillery, N. A.	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C.	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	Coast Artillery School	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Santa Fé, N. M.
Young, R. L.	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Aberdeen, Md.
Zeckwer, J. R.	Ensign	U. S. Naval Reserve Force	Ship Inspection Office, Philadelphia
*****Zinn, George A.**	Colonel	District Engineers' Office, Custom House	Portland, Oregon

* Army and Navy member.

JUNIOR SECTION

Wilmer Z. Kline, Chairman

MR. W. Z. KLINE, Chairman of the Junior Section, announces that the following men have been appointed chairmen of the several committees and will form the Executive Committee for next season:

E. M. Bredin	Secretary of Junior Section
Albert Godsho	Chairman of Papers Committee
Mathew Kennedy	Chairman of Membership Committee
Frank Boettcher	Chairman of By-laws Committee
Ralph Bye	Chairman of Meetings Committee
E. K. Spring	Chairman of Finance Committee
H. B. Nicholson	Chairman of National Service Committee
M. G. Bittel	Chairman of Publication Committee
Edward Noppel	Chairman of Entertainment Committee
H. I. Goldstein	Past Chairman

These men have all accepted the appointments and will immediately begin forming their committees. It is hoped that the Junior Members will do everything possible to assist them in their various undertakings so that next year's Junior record will surpass that of this year.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS ∴ PHILADELPHIA SECTION

Nathan Hayward, Chairman

H. Mouradian, Secretary, 1631 Arch Street

THE annual meeting of the Philadelphia Section was held at the Engineers' Club on June 10th. The election of officers for the following year was announced by the Chairman as follows:

Chairman	W. F. James
Secretary and Treasurer	E. B. Tuttle
Assistant Secretary	R. D. Thomas
Managers	C. E. Clewell N. E. Funk L. H. Rittenhouse

We had the pleasure of having with us Mr. F. L. Hutchinson, Secretary of the Institute, who gave a very interesting summary of the work of the Institute membership in connection with the war.

It was announced at the meeting that the Section meetings were unusually well attended this year, with an average attendance of one hundred and forty-eight. The Membership Committee reported an increase of eighty-five members, a second prize being awarded to the Philadelphia Section for its activities in the way of securing new memberships.

PHILADELPHIA SAFETY COUNCIL

LOCAL SECTION No. 7 OF NATIONAL SAFETY COUNCIL

J. F. CONNER, President

J. P. MUDD, Secretary-Treasurer,
The Midvale Steel Co., P. O. Box 1322

A VERY successful joint meeting of the Philadelphia Safety Council and the Illuminating Engineering Society was held on Friday evening, May 17, 1918, at the Engineers' Club, 1317 Spruce Street, Philadelphia.

It is hoped that our next year's schedule may contain several joint meetings, where the subjects will be interesting to both societies concerned.

As soon as the dates of the next year's meetings are given out by the Philadelphia Engineers' Club, the Philadelphia Safety Council Committees will begin listing the meetings for next year. Anyone having suggestions for possible subjects and speakers will confer a great favor upon the Council by writing direct to the Secretary, whose address is given above. Needless to say, we are looking forward to next year being bigger than ever before. The first meeting will probably be held some time in September, and if we are correct in judging from indications, the Philadelphia Safety Council meetings will be the "livest" of any of the affiliated societies.

The Local Section desires to acknowledge its appreciation of the help and suggestions received from Mr. W. H. Cameron, of the National Safety Council, and for his kindness in sending to us his Secretary, Mr. F. M. Rosseland.

Four of the papers of the Philadelphia Safety Council have been published during the past year in the Engineers' Club JOURNAL. Probably more will be published during the coming year.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS ∴ PHILADELPHIA SECTION

C. N. LAUER, Chairman. JOHN P. MUDD, Secretary, Midvale Steel Company, Nicetown, Pa.

A MEETING of the Philadelphia Section of The American Society of Mechanical Engineers was held in the auditorium of the Engineers' Club, at 8.15 P.M., Tuesday, May 28.

A Nominating Committee was appointed, consisting of:

D. Robert Yarnall, Chairman
A. C. Wood
Coleman Sellers, Jr.

After some deliberation, the Nominating Committee selected the following men:

For Chairman	C. N. Lauer
For Secretary	John P. Mudd
For Executive Committee	H. B. Taylor L. F. Moody W. B. Murphy L. H. Kenney

Later, tellers were appointed, as follows:

P. P. Henshall
L. L. Hepburn
Leo Loeb

A letter ballot was mailed to the entire membership, and the replies counted by the tellers, who reported that the ticket as presented by the Nominating Committee had been elected. A total of fifty-five ballots were cast, four of which were void on account of omission of voter's name on outer envelope.

At this meeting, P. P Henshall was appointed as Correspondent for the A. S. M. E. Journal.

Mr. E. B. Carter was appointed as a committee of one to audit the secretary's accounts.

An excellent paper, "The Manufacture of Ordnance Forgings," was given by George Satterthwaite, Vice-President and General Manager of The Tacony Ordnance Corporation. The paper was illustrated thruout with lantern slides.

The speaker outlined the very excellent progress which had been made in building the new plant of the Tacony Ordnance Corporation. In spite of the very severe winter, the building operations have progressed favorably and all of the shops have been completed. They were having, however, considerable difficulty in getting equipment.

A vote of thanks was extended to Mr. Satterthwaite.

Moving pictures, showing in detail the manufacture of 9.2 high explosive howitzer shells were shown. These films were loaned thru the courtesy of "*Machinery.*"

Pag. O.K.

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-8 AUGUST 1918 NO. 165

A NEW METHOD OF SEPARATING SLATE FROM COAL *

By H. M. CHANCE, Member

Various other devices used for separation of slate from coal. Difficulties arising under these methods—Imperfect separation, loss of product, high unit costs. New method effects separation by means of agitated mixture of sand and water constituting a fluid mass of relatively high specific gravity, in which the coal floats and the slate sinks. Application of this principle to other ore dressing problems.

THE method and apparatus which is the subject of this paper has been invented and developed by Thomas M. Chance, of Philadelphia, a member of this Club, who is now in the National Service.

In order to illustrate clearly the difference between this new method for separating impurities such as slate, fire-clay, pyrite, etc., from coal and those in present use for this purpose, we will briefly review the types of apparatus now used in preparing coal for market.

HAND PICKING

The most simple way in which to remove slate, etc., from coal is to pick out the impurities by hand, and in some localities all of the coal is prepared in this way. When this method is used the coal is allowed to slide down chutes, aprons, or " telegraphs " in the form of inclined troughs, along which boys or men are stationed to pick out the slate and other impurities; or the coal is transported by means of travelling belts or picking tables past the slate-pickers.

BRADFORD BREAKER

Coal is often prepared for cooking by the use of a "*Bradford breaker.*" This is a large slightly inclined revolving screen, which breaks the coal by continuously dropping it from shelves arranged lengthwise on the inside of the screen, the coal being thus broken to a size that permits it to pass thru the screen perforations, while the slate or rock is not broken small enough to pass thru the perforations and is discharged out of the lower end of the screen. Apparatus of this type can be used only when the coal is relatively soft and the slate is relatively hard or tough.

COAL WASHERS

In the preparation of coal by washing, many different types of apparatus are used, the most simple of which is known as the " trough washer," which is merely an inclined trough or sluice with riffles on the bottom of the trough. The coal is fed in at the upper end of the trough together with a stream of water sufficient in volume to carry the coal over the riffles and down thru the trough, but not sufficient to move the heavier materials, such as slate, which settle between the riffles or in pockets provided along the bottom of the trough. Automatic means for discharging the slate that accumulates in the pockets or riffles are provided in some trough washers, and some forms of washers are equipped with a flight conveyor working on the bottom of the trough, which continually scrapes the slate upwards in a direction opposite to the flow of the water, discharging the slate, etc., from the upper end of the trough. Other forms of trough washers have been used with spiral conveyors or other means of maintaining agitation of the coal to insure the more efficient separation and removal of the impurities.

The operation of trough washers is analogous to, if not precisely similar to, that of sluices used in the working of placer gold deposits.

Another type of washer, which employs a vertically rising current of water together with mechanical agitation to effect the separation, has been used and is usually termed the "*Robinson*" washer because the Robinson washer was the most highly developed machine of this kind. This machine consists of a large conical or funnel-shaped vat or tank with provision for trapping out the slate and other impurities from the bottom. Provision is also made for passing a large volume of water into the bottom of the tank so that the lighter material, *i.e.*, the coal, is buoyed up by the velocity of the ascending water and only the slate and heavy impurities sink to the bottom. To effect this result without the use of enormous and prohibitive quantities of water, the machine is provided with a centrally located vertical revolving shaft with horizontal or inclined arms which keep the whole mass agitated. In this machine the coal flows over the lip at the top of the apparatus, together with the water pumped in from below, and this water commonly is returned to the pump and is continuously pumped thru the machine, sufficient water being added to make up for what is lost and to insure the water being kept relatively clean—that is, free from clay and coal dust held in suspension. This washer uses the principle which in ore-dressing is known as "upward current classification," in which separation is effected by differences in the velocity with which materials of different specific gravity fall in an upwardly moving current of liquid. This type of washer in some cases has been quite successfully used, altho only a relatively small number have been built and installed in this country. The writer is under the impression, however, that very few machines of this type are now in use.

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*Presented at special meeting, Engineers' Club, April 2, 1918.

JIGS

In almost all coal fields where coal is washed before shipment the appliance most used for this purpose is some type of jig. This may be described as a tank containing a horizontal or slightly inclined sieve or screen upon which the separation of the material is effected by vertical oscillations or pulsations of the body of water with which the tank is filled. These pulsations are produced by any suitable means, usually by a plunger or piston working in a compartment connecting with that in which the material is to be separated. In other forms the sieve or screen forms the bottom of a tray or box which is moved up and down rapidly, usually by means of rods by which the tray is suspended, which in turn are actuated by eccentrics or cams on a revolving shaft located above the tank. In both of these types of jigs the coal and slate are thus moved upwards and allowed to fall into the water, the heavier material sinking and forming a layer lying upon the screen or sieve and below the coal. The coal and slate thus separated are removed continuously or periodically by any suitable means.

Jigs work best on a closely sized material in which the individual particles are of approximately the same shape, and may fail to work on flat coal, which by turning on its edge may sink into the slate, or on flat slate, which if lying nearly horizontal may often be buoyed up and remain with the coal.

One of the difficulties in operating jigs is due to the fact that if the slate be drawn off too rapidly coal will also be drawn off and discharged with it, and, *vice versa*, if the slate be drawn off too slowly then a portion of the slate will be discharged with the coal.

One of the principal objections to the use of jigs in the preparation of coal for domestic use is the attrition to which the coal is subjected by being pounded up and down 60 to 180 times a minute from the time the coal is fed into the jig until it is discharged, a period commonly of from one to five minutes, depending upon the rate at which coal is being run thru the machine. This results in the breaking of tender coal and in the chipping off of the corners of brittle coal, causing a material reduction in size and weight of the finished product. In the preparation of anthracite coal the jig loss—that is, the loss in weight of merchantable sizes, represented by the buckwheat, rice, barley and culm (small sizes of use only as steam coal and saleable only at greatly reduced prices) caused by attrition in the jigs—has variously been estimated as ranging from 3 to 20 per cent.

"SLATERS"

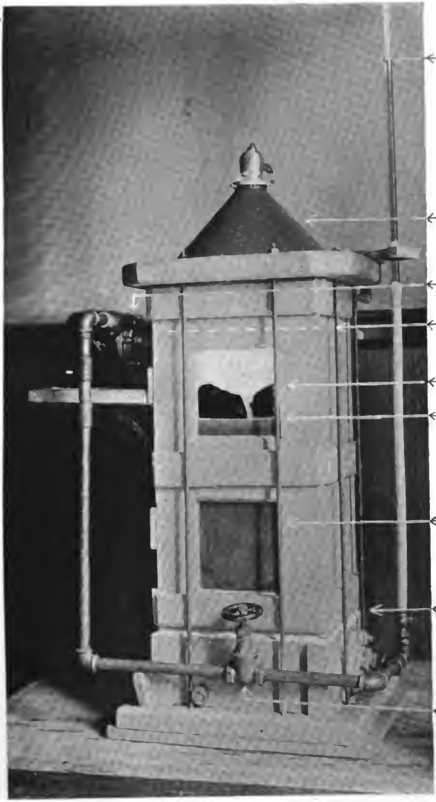
Other mechanical devices for separating slate from coal are "spirals," "air-gap" slaters, and slot slaters. Spirals and "air-gap" slaters utilize the difference in velocity of coal and slate sliding down by gravity over an inclined surface. Slot slaters are used to separate *flat* slate by passing the coal over narrow slots thru which the coal cannot drop but thru which the flat slate can readily fall.

CONCENTRATORS

Concentrating tables and bumping tables of various types similar to those used in ore-dressing have been used in washing coal for making coke, where, in order to eliminate the pyrite, it is necessary to crush the coal to fine size so that much of the material is too small to be treated successfully in jigs.

NEW METHOD

All of these methods depend upon differences in the kinetic energy developed by the individual particles of material to be separated, or upon differences in the falling velocities of the individual particles in water when subjected to a force such as upwardly rising or pulsating currents of water. They may therefore all be classed together as *kinetic methods of separating*, while the method which will now be described can be termed a *gravimetric method*, because it depends



Height of water in tube shows pressure under which water is supplied to bottom of apparatus below the perforated brass plate, thru which it issues as jets that keep the sand and water above this plate constantly agitated, thus producing a fluid mass of high specific gravity

Electric light to illuminate the interior

Electric motor driving centrigugal pump

Top of clear water in the apparatus

Lumps of coal floating in fluid mass, about one-half in sight

Top of fluid mass consisting of an agitated mixture of sand and water

Material seen in window is the lower part of the fluid mass; evidences of the jets can be seen in left half of window

Brass plate with perforations 1/16 of an inch in diameter and spaced 1 inch apart

Valve to regulate pressure and volume of water pumped from the top of the apparatus into the chamber below the perforated brass plate upon differences in the specific gravity of the particles to be separated, and consists in immersing the materials to be separated in a fluid mass whose specific gravity is less than that of the heavier material and greater than that of the lighter material.

If we introduce coal, ranging in specific gravity, say, from 1.30 to 1.50, into a fluid mass whose specific gravity is 1.60, it is evident that all of the coal will float, and that if the coal contains particles of slate the specific gravity of which, for example, is from 1.70 to 2.40, all of the slate will sink. It is also evident that this separation will be entirely independent of the size or the shape of the individual particles of coal and of slate, because the smallest particles of slate will sink in such a fluid mass and the largest lumps of coal will float in such a fluid mass, and flat slate will sink and flat coal will float in such a fluid mass. In other words, there will be in this case no tendency to a buoying up of the particles of the materials by reason of the shape of the particles, such as occurs in jigs. It is also evident that when materials are separated by introduction into such a fluid mass there will be practically no loss from attrition by the rubbing of particles upon each other, such as is experienced in the operation of jigs.

HIGH GRAVITY LIQUIDS AND SOLUTIONS

Suggestions looking to the use of a specific gravity method for separating coal from slate and metallic ores from waste material have often been advanced, and many attempts have been made to find some liquid or fluid of sufficiently high specific gravity to be used for these purposes, and many experiments have been made to produce some such chemical solution of relatively high specific gravity.

It is, perhaps, unfortunate that there are no cheap and innocuous solutions known that are of high enough specific gravity for use in the commercial separation of slate from coal. A solution of zinc chloride is frequently used in the laboratory for experimentally determining the possibilities of separating coal and bony coal and slate in order to learn in advance of the building of a jigging plant as to what kind of a separation it may be possible to effect. The zinc chloride solution is admirably adapted to this purpose, but for many reasons it cannot be used for making commercial separations on a large scale.

The use of a solution of any kind, or of a liquid of high specific gravity, would be objectionable, because much of such liquid or solution would inevitably find its way into the pores and joint planes and cracks in the material to be separated and large quantities of wash water would be required to remove this material, and this would involve the loss of a portion of the chemicals used in making the solution. The use of such solutions would also probably cost much more than can be expended in improving the grade of fuels used for ordinary purposes. Other chemicals have been suggested and experimentally tried out on a laboratory scale, but the writer does not know of any examples of actual value in practice of chemical solutions of high specific gravity for the commercial separation of slate from coal.

HIGH GRAVITY FLUID MASS

The present invention is based upon the fact that if any relatively finely divided insoluble material—such, for example, as sand—be mixed with a certain quantity of water and if the mixture be continuously agitated, the mixture will assume and preserve fluidic properties, and will exhibit the physical characteristics of a true liquid of high specific gravity.

If a mixture of sand and water in certain definite proportions be made and the mass be subjected to continuous agitation by means of stirring arms, propeller blades or any type of mechanical agitator, it is found that a fluid mass of definite specific gravity is produced. If the quantity of water be increased, the specific gravity of the fluid mass is decreased; if the quantity of water be decreased, or the quantity of sand be increased, the specific gravity of the resulting fluid mass is correspondingly increased. We have found in practice that such fluid masses can readily be produced by the use of sand similar to the seashore sand of the New Jersey coast, and with such mixtures we can in this way obtain fluid masses having specific gravities up to about 1.72. It seems theoretically possible to increase the specific gravity of the mass so obtained (by the addition of more sand) up to a gravity of about 1.80 more or less, and this may perhaps be possible in practice. The gravity can of course be reduced by increasing the quantity of water or decreasing the quantity of sand.

In producing and maintaining fluid masses of high specific gravity by this means, it is evident that mechanical energy must be supplied sufficient to counteract that which would be produced by the falling of the mass of sand employed thru water of the depth used, so that the sand is raised and kept mixed thruout the mass of water and the tendency to fall to the bottom is thus reduced, neutralized, or eliminated.

It is, of course, evident that if sand heavier than seashore sand (which consists mainly of quartz grains), such as magnetic iron ore sand, be used, the resulting fluid mass will have much greater specific gravity, and we have found in practice that by the use of materials of this kind fluid masses of specific gravity sufficient to float quartz, feldspar, and other rock constituents (which constitute the gangue of metallic ores) can readily be obtained. In using such heavy gravity fluid masses in the treatment of ores the waste would float and the heavier or more valuable minerals such as copper, lead, or zinc minerals, etc., would sink to the bottom of the fluid mass.

It is not, however, intended to enter upon a discussion of the use of this method for the separation of ores from waste, but to confine the paper to the separation of slate and other impurities from coal, and to demonstrate by the exhibition of a test cell the production of such fluid mass by the agitation of sand in water and to show the separation of slate from coal by the introduction of these mixed materials into the fluid mass contained in the apparatus.

As the production and maintenance of such fluid mass is dependent upon continuous agitation to prevent settlement of the sand of which the fluid mass is composed, and is not dependent upon the way in which this agitation is produced, it is evident that any suitable means may be used for producing agitation. In the apparatus in which the demonstration will be made, agitation is produced by small hydraulic jets, *i.e.,* small jets of water introduced under pressure thru perforations in the bottom of the receptacle containing the fluid mass. This type of apparatus, that is, one in which hydraulic jets are relied upon to produce the required agitation, seems best adapted for demonstration, because there are several features which can be illustrated more readily than in apparatus where agitation is produced mechanically. It will be understood that while agitation may be effected by water pressure alone, either in the form of large or small jets acting upwardly or in any other desired direction, that a combination of hydraulic agitation and mechanical agitation can readily be used.

The apparatus (see illustration on page 373) exhibited consists of a water-tight wooden tank or box, 20 inches high and 6 inches by 8 inches inside dimensions, which is open at the top and is closed at the bottom with a brass plate 3/8 inch thick and perforated by round holes 1/16 of an inch in diameter and spaced one (1) inch apart, there being 48 such holes thru which the hydraulic jets issue. Below this box and brass plate there is a wooden water-tight pressure box (of which the brass plate forms the top) into which water under pressure is introduced. The water issues under pressure thru the small holes in the brass plate and maintains continuous agitation of the fluid mass contained in the apparatus. The apparatus is supplied with an overflow located about 3 inches below the top of the box, thru which the surplus water is discharged. This overflow is directly connected with the suction of a small motor-driven centrifugal pump, and the delivery end of this pump is connected by piping with the pressure box at the base of the apparatus, so that agitation is effected by the continuous pumping of the same water from the overflow into the pressure box. The wooden tank or box is provided with two windows 5 inches square, one located near the top of the box and the other near the bottom, thru which the action of the fluid mass and of any material floating upon it can be seen and studied.

In operating this apparatus to make the most satisfactory demonstration, the amount of sand introduced into the apparatus is such that at the pressure used, the top of the agitated fluid mass (consisting of a mixture of sand and water) will be at a point about one inch above the base of the upper window, because if the fluid mass be maintained at this height, we can study the action taking place thru the upper window to best advantage. The fluid mass being maintained at this height, the clear water overlying the fluid mass from the surface of the fluid mass up to the water overflow is about four inches deep.

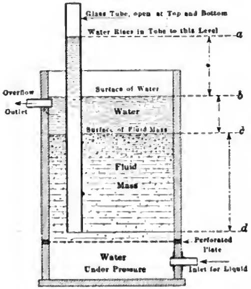
The pipe leading from the discharge of the centrifugal pump to the water pressure chamber at the base of the apparatus is provided with a valve to control the quantity and pressure of the water supplied to the pressure box, and a manometer gauge, consisting of a glass tube, is connected to this pipe near its entrance to the lower pressure box to measure the head or pressure under which the water is being supplied to the pressure box. The pressures under which the apparatus will be operated range from about twelve to twenty inches as the effective hydrostatic pressure by which agitation is effected. This is evidenced by the height to which the water in the glass manometer tube rises above the level of water in the apparatus, as determined by the overflow pipe.

The specific gravity of the fluid mass will be reduced whenever pressure of the hydraulic water is increased, such increased pressure resulting in a larger quantity of water passing into the apparatus supplying additional kinetic energy (agitation) and causing the level of the top of the fluid mass to rise. This rising of the top of the fluid mass indicates a dilution of the fluid mass by additional water and must of course result in lowering the specific gravity of the fluid mass as a whole, and *vice versa,* if the pressure under which water is supplied to the pressure box be decreased, the top line of the fluid mass will sink, and the specific gravity of the fluid mass will be correspondingly increased. It is further evident that so long as the quantity of sand in the apparatus remains constant and the hydrostatic pressure under which water is supplied to the apparatus for agitating such fluid mass be maintained constant, the specific gravity of the fluid mass will remain unchanged. In other words, it is possible in this way to produce and to maintain a fluid mass of definite specific gravity for an indefinite period.

In demonstrating the action of the fluid mass in the apparatus in operation we now show the flotation of both anthracite and bituminous coal by putting into the apparatus pieces of such coal from one inch to three or four inches in diameter. It will be observed that the bituminous coal floats much higher out of the fluid mass than the anthracite coal, this result being naturally due to the fact that the anthracite coal is of much higher specific gravity (*i.e.,* heavier) than the bituminous coal. The coal which is being used for this demonstration is anthracite coal from the anthracite coal fields of Pennsylvania and bituminous gas coal from the Pittsburgh bed as mined by the Westmoreland Coal Company in the western part of the State of Pennsylvania.

This demonstration is sufficient to show how buoyantly the coal floats in such a fluid mass. If a lump of the coal be pushed down far below the surface of the fluid mass it rises to the surface very much as a block of wood will rise to the surface if immersed to some depth in water.

The extraordinary fluidity of this fluid mass of sand and water is not readily comprehended and no real conception of its fluidity can be obtained by a mere description. If the hand be plunged down thru the superincumbent water into the fluid mass it is almost impossible to tell by any sensation one may experience as to when the fingers pass thru the water and enter the fluid mass. In fact it has frequently happened that this experiment has been tried by an observer having his back to the machine so that he could not see the separating line between the water and the fluid mass, and in many cases the hand has been completely immersed in the fluid mass without the fact being detected or known to the individual who was making the experiment.



SP. GR. OF FLUID MASS = $\frac{ab + cd}{cd}$

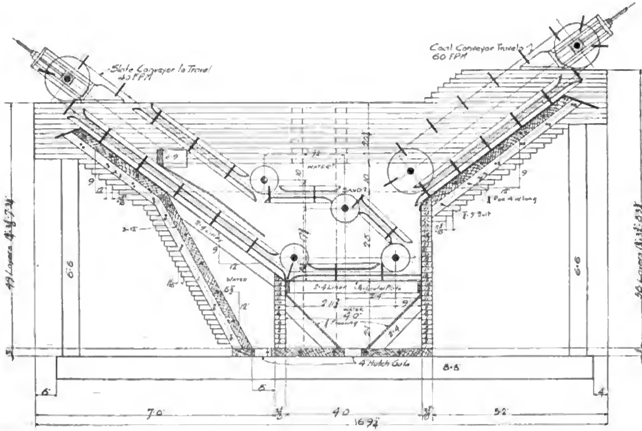
This fluid mass will float an hydrometer, and its specific gravity can be determined in this way. We have, however, incidentally discovered another method by which the specific gravity may be most accurately and definitely measured, and this consists in immersing a glass tube open at the top and bottom into the apparatus, so that the bottom of the tube is immersed ten or twelve inches below the top of the fluid mass. If the tube be held or secured in this position it will be found in a few minutes that the water will begin to rise in the tube until it has risen several inches higher than the level of the water in the apparatus. This is due to the fact that as the tube has no overflow, there is no upwardly rising liquid inside the tube, and the sand contained in the fluid mass within the tube gradually sinks to the bottom of the tube and joins the fluid mass external to the tube, so that the tube becomes filled with water, but as the water has a specific gravity of 1.0 and the fluid mass external to it has a higher specific gravity, the increased pressure at the bottom of the tube due to the higher specific gravity of the fluid mass forces water up into the tube until it finally stands at a height several inches above the top of the water in the apparatus. As the weight of the water overlying the fluid mass in the apparatus exactly balances the weight of the water in that part of the tube which is between the top of the water line and the top of the fluid mass, that portion of the water in the glass tube between these two points may be ignored, and we may say that the water in the part of the tube immeresd in the fluid mass, that is to say ten inches, plus the height of the water in the tube above the water line, if added together represent the weight of a column of water which is sustained by the weight or pressure generated by the fluid mass from the top line of the fluid mass down to the base of the tube. If the tube be immersed in the fluid mass ten inches and the water in the tube rises six inches above the water line in the apparatus, then we have sixteen inches as the weight of water column which is supported by the hydrostatic pressure developed by ten inches of the fluid mass, and the specific gravity of the fluid mass is therefore sixteen divided by 10, or 1.60. Further, as the column of water six inches in height above the water line in the apparatus is supported by the increased weight of ten inches of the fluid mass and as this increased weight (or increased specific gravity) of the fluid mass is due to the weight of the materials held in suspension in said fluid mass, it is evident that this column of water six inches high measures the weight of the materials held in suspension in the ten inches of fluid mass measured from the top of the fluid mass to the base of the glass tube. It thus becomes possible to determine the weight of materials held in suspension in a fluid mass of this character without knowing the kind or character of such materials, that is, whether they be heavy or light, and whether they consist of grains of quartz sand or grains of magnetic iron ore.

We have constructed a small apparatus to show the actual separation of the slate from coal in this test cell which has just been described, and this consists of a square cage, the sides and bottom of which are made of one-quarter inch mesh brass wire screen. This cage is about eighteen or twenty inches deep from top to bottom and about four or five inches wide by six or seven inches long, and is closed at the bottom and open at the top. About six inches above the bottom it is provided with double folding doors, which when closed constitute a floor or partition. These doors are also made of one-quarter-inch mesh wire screen, and are provided with stiff wire rods by which they can be opened and closed. In using this cage to demonstrate the separation of coal and slate, the coal and slate to be separated are placed in the cage resting upon the double doors which are kept closed, and the cage is then lowered into the apparatus until the coal is immersed below the top of the fluid mass. The doors are then opened by releasing the wire rods holding them in place. Upon opening the doors the slate sinks thru the fluid mass to the bottom of the cage, while the coal remains floating in the fluid mass at or near its top. The double doors are then closed by bringing the wire rods back into their original position and the cage is then removed from the apparatus. In bringing the cage up out of the apparatus it is slightly shaken while being passed thru the water overlying the fluid mass in order to wash off any sand which may be adhering to or resting upon the coal. Upon thus removing the cage the coal is found resting upon the doors in its original position, but the slate is found in the bottom of the cage. The coal can then be emptied from the cage and after this is removed the doors can be opened and the slate removed for examination.

The author then made a demonstration with the apparatus, separating anthracite coal from slate, by placing in the cage a quantity of chestnut coal and slate, immersing the cage in the fluid mass as described, removing the cage and emptying the coal and slate into separate pans, the whole operation being completed in about fifteen seconds. The separation was perfect, the coal containing no slate, and the slate containing no coal, and the separated products were passed among the audience for examination.

The test cell used to illustrate this paper and by which the demonstration has been made was constructed for experimental purposes in determining the volume and quantity of water required to operate the method with different kinds of material and when agitation is produced by hydraulic water. It is not intended as a model of a machine such as would be used for the commercial separation of slate from coal, because it is not provided with means for mechanically introducing coal into the apparatus and for mechanically removing the coal and slate after separation is effected. Machines for operating this method can be constructed to operate continuously, the material, coal and slate, being fed in at one point and after the slate had been separated the coal can continuously be removed, while the slate can also be continuously (or periodically) removed from some lower portion of the apparatus.

The commercial development of the method is now



being pushed in two or three directions and I am able to show a design of a machine the construction of which is now practically finished and which we expect will soon be installed for regular work in the separation of coal from slate. This design is not intended to illustrate the best or only method of constructing such machines, but to show the general principles involved in the construction of machines for commercial use. This machine is designed to be operated mainly by hydraulic agitation. It will be observed that the coal is fed into the machine at the top line of the fluid mass by a flight conveyor of standard type, and this same flight conveyor carries the coal gradually across the machine, while the lower run of this same conveyor is used to remove the slate. A second flight conveyor is used for removing the coal from the machine. While hydraulic agitation by means of perforations in the base is mainly relied on in this machine, a certain degree of mechanical agitation is also obtained by the use of the flight conveyors and this will tend to prevent any banking or accumulation of sand in those portions of the machine in which separation is taking place.

In operating this machine certain supplemental devices will probably be used in the nature of sprays, located at or near the points at which the coal or slate is being discharged, to wash off the particles of sand that may adhere to either the coal or slate. Most of the sand will be washed from both the coal and the slate as these materials are being transported diagonally upwards thru the layer of water which overlies the fluid mass. It is also probable that pipes may be used inside the machine provided with perforations for supplying water under pressure, *i.e.*, jets, and placed in such position that the jets will be directed upon the coal and slate as it is drawn up thru the fluid mass and thru the water overlying the fluid mass. These pipes can be submerged in the water underlying the fluid mass or in the fluid mass itself, and used for the purpose of obtaining supplemental agitation and of directly washing sand from the slate and from the coal, thus reducing the quantity of sand carried along with the coal and slate by the conveyors used in removing these materials.

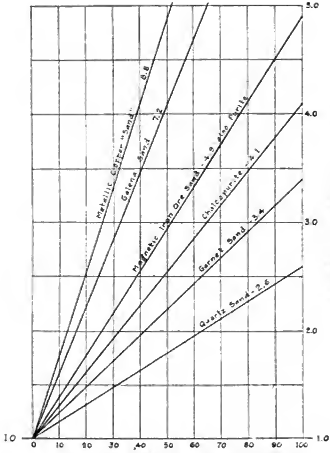


CHART SHOWING SPECIFIC GRAVITY OF FLUID MASSES CONSISTING OF AGITATED MIXTURES OF GRANULAR MATERIAL AND WATER

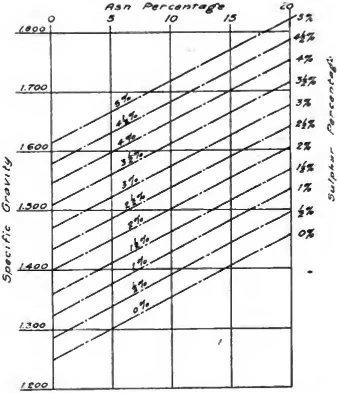


CHART SHOWING RELATION OF SPECIFIC GRAVITY TO ASH AND SULPHUR PERCENTAGE

BASED ON
Pure Coal, 1.250 Specific Gravity
Clay Ash, 2.300 Specific Gravity
1% Sulphur = 2% Fe.S₂ @ 4.900 Specific Gravity

While in the apparatus shown hydraulic agitation is effected by means of a perforated bottom, it will be understood that effective agitation can be obtained by jets from pipes inside the main tank and that these jets may be directed vertically downward, or at any desired angle.

The mechanical energy required to maintain agitation is surprisingly small. The quantity of water used in the apparatus shown is approximately about 1.3 to 1.6 gallons per minute or at the rate of about five gallons per minute per superficial square foot of area of

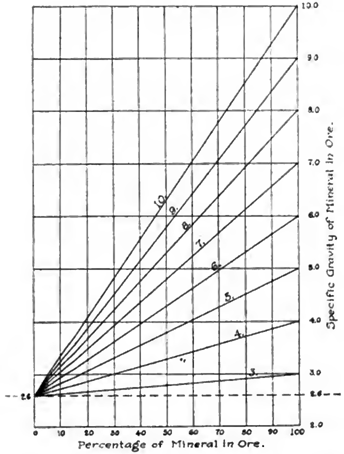


CHART SHOWING SPECIFIC GRAVITY OF ORES HAVING A GANGUE WITH SPECIFIC GRAVITY EQUAL TO 2.60

the agitated fluid mass. The water is supplied under a hydraulic head of about fifteen to eighteen inches, and the fluid mass has a depth of about thirteen inches. The mechanical energy required to maintain agitation in this test cell is say 1.5 gallon (or say twelve pounds of water) per minute under a head of 1.5 feet, or about eighteen foot pounds or 1/1833 (one-eighteen hundred and thirty-third) part of a H.P., or at the rate of 3/1833, or say 1/600 (one-six hundredth) part of a H.P. per superficial square foot of surface. If the depth of the fluid mass be increased to three feet the requirement would be about 1/200 H.P. per superficial square foot of the area of fluid mass used.

The diagrams used to illustrate the specific gravity of fluid masses using "sands" of different materials, the effect of sulphur (pyrite) and ash in coal upon its specific gravity, and the effect of heavy minerals upon the specific gravity of ore will be understood without explanation.

It is, however, of interest in this connection to note the possibility by this process of separating coal from "bony" coal, and of separating "bony" coal from slate, neither of which can be successfully done by jigs. It is possible to adjust the specific gravity of the fluid mass so that all "bony" coal rich in carbon will float with the coal, while bony coal that contains little carbon will sink with the slate. In the same way it becomes possible in treating bituminous coal to make a "three-part" separation, viz.: 1, highest grade coal, low in sulphur and ash and especially valuable for making by-product coke or for domestic use; 2, coal of medium grade as to sulphur and ash and suitable for general use as steam and heating fuel; 3, slate, fireclay, pyrite, and other impurities. A supplemental separation of the pyrite (for sale and use in sulphuric acid making) from the slate, fireclay, etc., can be made when the quantity of pyrite is sufficient to justify the additional cost.

It will be observed that the separation made by this method is a *perfect* separation; that the slate contains *no coal,* and the coal contains *no slate,* a result impossible to obtain with any method of separation in use.

It will also be evident that the mechanical energy required to operate machines of this kind will be far less than that required to operate jigs, and that the breakage from impact and attrition will be almost completely eliminated.

DISCUSSION:

DOCTOR CHANCE: If there are any questions anyone would like to ask, I would be very glad to answer them.

A MEMBER: What would be the capacity of the machine you just described?

DOCTOR CHANCE: We do not know the exact capacity, but Mr. G. H. Elmore, who designed and built this machine is present and I would like to ask him to answer the question.

MR. ELMORE: Doctor Chance has been very modest about his exposition of this invention. There are some features in connection with it, which he has not mentioned, that read like a romance. I am sure it is because his son was the inventor of it, and with your permission and the permission of Doctor Chance, I should like to take about ten minutes to tell you something more about this that he has not told you. The conception of this method came in a very strange way, and if there ever was a piece of "simon-pure" invention it was when Mr. Chance's son found out the great truths involved in this little piece of apparatus.

We have all seen it—I guess every boy has, in his younger and perhaps older days, when he has looked into a boiling spring, with water boiling up thru sand, seeing the sand staying at the same level, and boiling all the time. That is nothing in the world but this piece of apparatus, but nobody before thought of applying it until Mr. Chance's son, who had been experimenting for some little time with the zinc chloride solution,—as we all do in this art of making separations, had the thought come to him, as it perhaps has come to everybody else,—that if we could only find something with which we could do practically what we can do with zinc chloride, something that would not cost as much as the zinc chloride, we would have an ideal way of making such separations. He came back from his experiments with zinc chloride and with jigs, and went down to the shore with his family, and while out on the pier there one afternoon he looked down on the sand and saw the water agitating the sand and mixing with it, and the thought came to him, "That has a greater specific gravity than water. I wonder if coal would not float in that mixture." So when he went back to the house, he took some of the seashore sand, put it in a washtub, and in his back yard, used the jet from his garden hose to agitate the sand, and then threw pieces of coal into this mixture of sand and water and found that the coal would float. That is the way this was discovered. I say it is a "simon-pure" invention if there ever was one. Some time ago I became interested in the matter, and I am now putting up the machine shown on Page 377.

Just one more word in regard to what this will do in the anthracite business. That is what I am interested in,—what this will accomplish in the anthracite trade. I can say frankly and candidly after the most careful study of this method, and judging from my experience in the business of coal washing—and it has been practically the work of my life—that I am more and more convinced that this is going to be worked out successfully and practically for use on a large scale. If you buy a ton of anthracite coal in ordinary times (and let me make that distinction, not war times but ordinary times) you get a very carefully prepared commodity. The expense that the anthracite operators incur in preparing coal is stupendous. Those of you who have never been in an anthracite coal breaker and who have never seen what processes the coal is put thru, have no idea of what these operations cost. It would be practically impossible to make any better preparation of the anthracite coal as it comes to you in ordinary times without enormously increasing the cost of the coal. When they reduce the quantity of the rock and slate in the coal to within two per cent. in egg coal, three to three and a half per cent. in stove coal and three and a half per cent. to four per cent. in chestnut coal, they have reached the limit under present methods in use; take my word for that. To do any better would make the coal cost you very much more per ton, and it is impossible for the arthracite companies to furnish you pure anthracite coal, in so far as slate is concerned, without making the cost absolutely prohibitive.

When this apparatus is used, the coal will contain no slate. It is not impossible that some of the coal may settle and go with the slate, for this will depend on the proper operation of the machine, but it is physically impossible for any slate to rise and float with the coal; therefore, it is perfectly certain that you will not get any more slate in the coal. Now, there is another thing that is going to happen. I have always thought of those two great moral questions which are involved in the preparation of anthracite coal. It is wrong to sell a man something that is absolutely valueless to him. It is wrong in principle, but the operators have been unable to avoid it. This will overcome that. It is equally wrong and wicked to grind up and waste in sludge, millions of tons of coal a year, as is inevitable when the bone or high ash coal is recrushed and sold in the steam sizes. When, however, this new method is in successful operation it will be possible to save the bone that is in the coal in the prepared sizes. It is wicked to grind it up and waste it, for you ought to buy the bone and pay for it and burn it, but you ought not to buy a pound of slate.

These are two great moral questions that this process will settle and settle right. Therefore, I think the whole design and system of preparing anthracite will be revolutionized. This method does not depend upon sizing, whereas we now have to do very accurate sizing. It will simplify the breakers enormously. It will reduce the cost of preparing the coal enormously. It will give an added value of from thirteen to twenty cents a ton to the output of anthracite companies as compared with what they are doing now, because they can save the bony coal without breaking it up into the smaller sizes which have very small value per ton and which is an added expense to them to handle. More than that, it will reduce the breakage in preparation and be in every way a great benefit to the producer as well as to the consumer. I look forward to a wonderful development with this simple piece of apparatus.

THE CHAIRMAN: How soon will this be operating, Doctor?

DOCTOR CHANCE: Mr. Elmore is having some difficulty in getting this machine completed. It is very difficult in these times to get new work done. If we want patterns made, or a special job of casting of one or two parts, we find it to be very difficult to get such things done promptly, but we hope to see the machine installed and in use within the next month or two.

MR. ELMORE: Yes, less than that, Doctor.

DOCTOR CHANCE: Perhaps,—but Mr. Elmore is an optimist and his hopes may not be realized.

MR. NICHOLS: The question was one of the size and capacity of the machine.

MR. ELMORE: Nobody knows that accurately, because we have not tested out a full-sized machine; but, this is evident—you put a mixture of slate and coal in it and the job is done at once: it either floats or sinks,—instantaneously. Therefore, it is mainly a question of getting the best type of apparatus, and I am not at all sure that this design will give us the best type of machine. It is only a question of getting apparatus that will remove these particles of slate and of coal from the machine without destroying the action of the machine itself. As soon as we can do that we will know the capacity of the machine. There is no limit to the width you can build these machines. I think we can readily build machines that will handle from 50 to 100 tons an hour.

AMERICA SEEING IT THRU*

By HONORABLE WILLIAM HOWARD TAFT

The grounds for hope:—Loyalty of our naturalized citizens—our readiness to acknowledge errors and missteps; the energy and honesty in seeking corrective measures; the selective draft.

WE must maintain the solidarity of public opinion. We must anticipate the insidious weakening that comes from disaster and the lure of suggestions of inconclusive peace, and we must study the questions of the solidarity of public opinion and strive by our propaganda to keep it constant.

There are some things which have come under my observation, or to my information that I would like to suggest, with reference to this solidarity of public opinion. In the first place, the changes toward the better condition than the one we seek are to be found in our naturalized citizens and those aliens who are waiting to be naturalized among the workmen particularly of this country. The steps taken in that regard, the changes in their attitude are most interesting to study, as we can derive information from them by the progress of the three Liberty Loans. The first Liberty Loan found them listless; the second a little aroused, and the third, to use an expression that I justify because of having heard it here before, finds them " on their toes."

In Cleveland and in other centres of crowded labor drawn largely from alien sources, I was surprised to hear the energy, and the spirit with which they rushed to the aid of the Government to subscribe to the Liberty Loan, so great indeed that in many of the establishments ninety-five or ninety-eight per cent. of the men had to be restrained with reference to the steps that they wished to take to compel the remaining five or two per cent. to make the subscription. They demanded that they be not compelled to work with men that did not appreciate the importance of the present issue.

Why was that? It is because those laborers were largely made up of men from the Slav countries, from Roumania, from Poland, from Russia, and from those countries that have felt the heavy hand of Germany and her Allies and who know that the Western drive is on, when they hear of the hurling of two or three millions of men against the Western front what the danger is, and they have come from countries where they understand what tyranny and militarism are. So it is that we can count on the support of those races who are not Germans, but who have felt the weight of German kultur.

With respect to our citizens of German origin, I think a word ought to be said, and a serious one. There came to this country early in the nineteenth century and in the latter part of the eighteenth century many Germans who were driven out of Germany because of religious intolerance. They settled in Pennsylvania and in New York, and there is no doubt about their loyalty.

Then there are those who came over and are the descendants of those who came over when the intellectual, forceful, liberty-loving Germans attempted to get rid of the twenty-eight different despots, emperors, kings and kinglets, dukelets and electors that loaded down divided Germany in 1848. They failed and then they came here because they wished to breathe in the air of freedom! They were led by Carl Schurz and Frederich Hasen. They left their country to avoid tyranny and militarism and they came here to breathe in the free air of constitutional government and to enjoy the pursuit of happiness under institutions of civil liberty. They loved liberty and when the Civil War came on, hating slavery as the antithesis of liberty, they enlisted largely everywhere and every battlefield was wet with the blood of our citizens of German origin. Now the descendants of those and others who have been added since have been exposed to a very difficult situation.

We were three years a neutral. We were three years in a condition where Germany and her propaganda widely spread had the opportunity of teaching lies on the subject of the blame for this war. They spread the propaganda among their German friends as they supposed that Germany was merely defending her possession and her right against a conspiracy of Europe. Because they were not as keenly alive to actual conditions in Germany as were their fathers and grandfathers, they felt pride in the great material steps that Germany had taken and the progress and prosperity that she had achieved. And so they had that natural disposition to sympathize with people whom at the time they regarded as in no way treasonable to their obligations to have such a sympathy.

Then the truth came out. Germany showed her cloven hoof and we were in the war. Many of us who are not Germans did not understand as fully as we now understand what were the issues of the act. We did not enter this war under any feeling of passion. We had three years of neutrality in which gradually to study what the real issues were, and when we entered it, it was under an intellectual conviction that we must go in as we had studied what the circumstances were. And so, these citizens of German origin found themselves within a conflict of emotion; they found themselves, by their sacred obligations, bound to make a fight against that country toward which they had the natural feelings of children. Therefore, we must be considerate with what has happened. The majority of them have been loyal to their sacred obligations.

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*Address delivered at the National Convention of the League to Enforce Peace, Philadelphia, May 17, 1918.

If among them there are some, and undoubtedly there are, who are forgetting their sacred obligation, who give aid and comfort to the enemy, there is but one course for this country to pursue and that is, after a judicial trial, to end their citizenship in any country.

But as to the great majority, we should be considerate. We should understand the unfortunate series of circumstances thru which they have come, and we should welcome them as responding loyally to their obligations. Their sons are in the army; they are contributing to the patriotic funds, and as the truth with reference to the contest on the other side reveals the hideous atrocities of those with whom they have kinship, they will become as solid and have as fine a sense of patriotism as any people in this country.

It is important that we should welcome them in order that we should have complete solidarity in this country in backing up our boys and their boys on the other side of the water.

So it is that I feel that we ought to speak with no uncertain sound with reference to the disposition to lawlessness growing out of some popular feeling in one part or another because some ass or some fool has given expression to disloyal sentiments when you cannot connect those disloyal sentiments with any conspiracy.

We are assuming, and we have a right to assume, to be a nation of Christian civilization, governed by the restraints of law. Now, of all things, when we blame the Germans for brutality and accuse them, as we may well accuse them, of atrocious conduct, let us keep our skirts clean and live under the rule of our nation.

So, let us frown upon that expression of loyalty that prides itself on brutality in its expression. The easiest thing in the world is the man who joins a mob; he is the easy mark; it is the cowardly spirit of cruelty that prompts him. Let us go on in due order. We have no war here flagrant that requires us to resort to measures so summary as to lack the attitude of justice. We are now having laws passed that give us an opportunity fully to punish even the most cursory expression of disloyalty. If those fools and asses and traitors that give such expression work three months or a year or three years on the rock pile, they can talk disloyalty to the rock pile, but I do not think it will do them any good. Now, we are seeing it thru. I am not here to criticize those who have been responsible for the administration of our war affairs; that is a matter for political discussion and elsewhere, but what I am here for is to, if I may, give a brief résumé of the ground for hope that we may have. There was a time when the rifles were short; now we have got beyond that and we have the best rifle that any nation has, with full ammunition and a full supply of all the rifles we need as our men come on to be equipped. We have been slow with our machine guns, but they are coming on. We have got to pay, my friends, and ought to pay willingly, for the privilege of a free Government, for a lack of German efficiency.

We are a wonderfully organized people—I mean from a business point of view and for the production of what we seek to produce in private business. It is only in the Government that we tolerate the proposition that a man may be entirely fitted for a position, the duties of which he knows nothing about. But we are a wonderfully adaptable people, at any rate, because we may put a man into an office entirely innocent of the field of his duties, who, after a reasonable amount of blunders, will become a moderately able man in that field. You will pardon me if I say that I have had some experience that justifies my statement. And so we are, to use an expression that has been applied in England, "muddling on" but, as the man who came out of the hotel and fell down the stairs, apparently under the effect of bibulous habit, when he gathered himself up with a somewhat sodden dignity, resented being lifted because he said he always came downstairs that way.

That is the way we have got into every war. But we have the foundation of courage and intelligence and capacity and patriotism, which in the end pulls us thru. And so it is with respect to the machine guns; in a measurable time, we shall be producing the best machine guns that the world has seen, and producing them in all the capacity needed to seventy-five millimetre guns and the heavier artillery.

One of the pleasures of being completely irresponsible and being right at home in the family is that we can admit our errors and our weaknesses. One of the troubles about us is what a polite stranger would call "unwarranted optimism," what really is a disposition to blow about what we can do. And so we have been blowing about what we are going to do, and have not done it. That is all. We sounded the trumpet without knowing the difficulties. They do not discourage us. We associate with that disposition to trumpet our excellencies and virtues and achievements an intimate knowledge of ourselves which robs us of any discouragement because we do not come up to our promises. And so it is that we are making slowly the progress that will ultimately bring about a supply of everything we need that will startle us and startle the world with its total.

So, with respect to ships we have had great discouragement and great delay; unnecessary it may be, but after we get going, we will put ships enough upon the sea that we will make a bridge of ships from here to Europe, that will carry all the army we need to raise, and in the meantime, we shall have made so many torpedo-boat dedestroyers and shall have learned so many means of organizing against the serpent of the sea, that we will end the enjoyment that the head of the German Potsdam gang has had in his piracy and murder upon the sea by the difficulty of securing gentlemen who wish to enter in that proposition.

And then, with respect to our men—one of the things to which this administration is fully entitled is the credit for the conscription law. It has been made the basis for the raising of an army that will win the war. In the outset, it was perfectly characteristic of us. We have such rare brains, with such power of discovery, that we were going to fight a war without exposing any of our boys to killing or wounding. We were just going to put up the money, just invent the instruments of destruction that somebody else was to use, and then we were to sit back and enjoy a comfortable time while we watched the victory won.

Now, that is a very true interpretation of the attitude of a great many people in this country. Now we are learning something. We are learning that in spite of all the changes in warfare, of all the modern improvements in warfare, battles are still fought and won by men.

We say, " Food will win the war." Well, that isn't a correct expression. Food will lose the war. We say, " Money will win the war." The absence of it may lose it. But the one thing that is affirmatively necessary is the red-blooded courage of men, and many men. That is what the conscription law offers. Under it, and it is a marvelous exhibition of the self-governing capacity of the American people, the man who drafted the law was General Crowder. He had confidence in it, in the intelligent action of committees and the selection in that community of men competent to act, and he threw the law on the people, and the people responded. In a marvelously short time, under his regulation, ten millions of men were registered, and out of that ten millions we have now been culling, we have divided them up under his regulations and questions into classes. The first class is of unmarried men and of married men who have no dependents, and those who have no useful occupation. I am not going to say how large a class that latter division of Class A is, but Class A represents those with no dependents.

We raised in that class 600,000 regular and 187,000 specific units, making 787,000, which added to the volunteers of the National Guard and the Regular Army made an army of 1,600,000.

That is an army which will have added to it 200,000 more in the course of training which we now have. It is the army that has been hurried to France. Class A is 2,400,000, or was when the first increment of 187,000 was drawn. Now we have an army of 1,600,000. Out of the 2,400,000 we now call in May and April for 600,000 more. That reduces that to 1,800,000. In the remainder of the year we shall call 800,000. That reduces Class A to 1,000,000 men. By the new law, we add thereto 700,000 of those who have come to be twenty-one years of age during the year since May of last year when the law was passed. With the addition to our present army of 1,400,000 drawn this year and drafted, we shall have at the end of this year an army of 3,200,000, and have left in Class A a million men undrawn. In the year 1919, by the operation of this new amendment, we shall gather in, as over twenty-one, 700,000 more men, making 1,700,000 in Class A for the increase during 1919, or with 3,200,000 in the army at the end of this year. At the end of the following year, we can add 2,000,000 and make an army out of Class A alone of 5,400,000 men.

Now, consider what that means. See what they have done in England and in France. They have called upon dependents. They have called on men up to fifty. They have called upon men who in this country would be exempted without a word, and yet we can put an army into the field of 5,400,000 men and only call upon the men between twenty-one and thirty-one, and those men who have no dependents at home.

Now, that is what I call seeing it thru, and if we need another army of 5,400,000 men, all we have to do is to reduce the age to eighteen and go into Class B with some who have dependents, and we can make an army of ten millions of men. Now, with that capacity, with our power of production, that this year and the year after will demonstrate our potentiality, aren't we ourselves to blame, must we not be held up to the shame of history if we don't win this war?

LIGHTING CURTAILMENT*

By PRESTON S. MILLAR

The coal used in the production of electric light is less than 2 per cent. of the total coal output of the country. Curtailment of lighting can therefore accomplish relatively little as a coal-saving measure. Standards of illumination intensity before the war were in general too low. In view of the war and the fuel shortage, lighting ought to be reduced in some classes of service and increased in others. Any practicable curtailment is about 3 per cent., which means about 360,000 tons of coal per annum, or a trifle more than five one-hundredths of 1 per cent. It is practicable to effect much larger savings by other methods with less disadvantage to the public.

THE most important thing is to win the war. The need for directing money, energies and materials toward the prosecution of the war makes it imperative that waste and extravagance be eliminated. Economy, in lighting as in other things, contributes to victory.

Economy involves adjustment of resources to secure the best results. As Ruskin has said, " Economy no more means saving money than it means spending money." Economy in lighting in the present circumstances depends upon:

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* Presented before the Philadelphia Section, Illuminating Engineering Society, February 15, 1918, at the Engineers' Club.

Illustrations courtesy of the Illuminating Engineering Society.

1. Securing best accomplishment of the results which the lighting is intended to bring about, subject to the need for
2. Reducing consumption of fuel by the elimination of unnecessary lighting and by reduction of other lighting so far as the emergency warrants. Emergency reduction should be undertaken after due consideration of
    - (*a*) the amount of fuel saving which can be accomplished,
    - (*b*) the disadvantages involved in the reduction, and
    - (*c*) the practicability of saving the same amount of fuel otherwise with less disadvantage.

THE PLACE OF ILLUMINATION IN OUR AFFAIRS

Artificial light makes possible practically all the nocturnal activities which go so far toward differentiating modern from ancient life. It facilitates and renders safe a wide range of industrial, educational and recreational activities which are of inestimable material and spiritual benefit to the country. A moment's contemplation of the curtailment of living which would ensue if there were no artificial light will convince of its invaluable and indispensable nature.

THE COST OF ILLUMINATION

The cost of artificial illumination of all kinds is ½ to 2 per cent. of the total expenditure of the people. It compares with certain other expenditures as follows:

Illumination	$500,000,000[1]
Liquors	665,000,000[2]
Tobacco	490,000,000[3]

The great value of artificial light to the public, and its small cost, are important considerations which ought not to be neglected when discussing lighting curtailment.

COAL CONSUMED IN ELECTRIC LIGHTING

The significant figures to have in mind when discussing this subject are as follows, all being rough approximations:

Approximate Coal Consumption for 1917

Total coal output of the country	640,000,000 tons[4]
Total employed in production of electric light and power (traction excluded)	45,000,000 tons[5]
Total employed for production of light by electricity (see note)	12,000,000 tons[6]

Fig. 1 is a representation of these quantities, which may assist in indicating relative magnitudes.

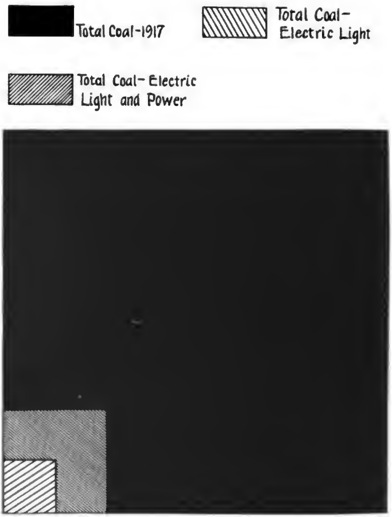

Fig. 1.—Coal consumption of the country

According to these estimates, about 2 per cent. of the coal consumption of the country goes into electric light. We are told that our consumption of coal must be reduced by 50,000,000 tons per annum.[7] If the entire electric lighting of the country were cut off the saving in coal would be only 24 per cent. of the required saving. In considering lighting curtailment therefore it is important to bear in mind that even if every candlepower of electric lighting were wasted the loss of coal involved would not be the great outstanding coal waste of which this country is guilty. As relatively little light is wasted, it is evident that the amount of coal which can be saved by curtailment of electric lighting is small. Our discussion has to do with the saving which it may be possible to effect in the 2 per cent. of the country's coal which is consumed in electric lighting.

PRESENT STATUS OF ARTIFICIAL LIGHTING

Before the present period of fuel stringency, the employment of artificial light had increased rapidly. In some classes of service it had attained a stage which in the present state of the art was considered by experts to be reasonably satisfactory with respect to intensity tho not so in respect to the manner in which the light was used. Such a condition, however, was exceptional. Upon the whole artificial lighting has been inadequate, considering the best advantages to the public. Safety, conservation of vision, economy in production, commercial success, and esthetics, singly and in various combinations, require improved utilization of artificial light which in many, if not in most cases involves the production of more light.

Within the past two weeks the author has requested a number of members of the Society to express their views as to the adequacy of standards of lighting practice. The consensus of the opinions secured[10] is presented in the following table:

Classes of lighting service.	Present day ideas of desirable practice as compared with practice just before the war. per cent.
Street (civic, not white way)	+ 70
Public buildings (schools, colleges, institutions, etc.)	+100
Industrial	+175
Protective (outside and inside)	+400
Commercial (offices, stores, etc.)	+ 40
Residence (including hotels, clubs, etc.)	+ 30
Recreational (churches, theatres, saloons, etc.)	0
Advertising (signs, white way, show windows, etc.)	0
Miscellaneous	+100

Assuming a certain distribution of illumination among the several classes of lighting service named[14] (see page 389) it develops that according to the consensus of opinion of these thirteen men, electric lighting as a whole ought to be increased by about 72 per cent. in order to conform to the consensus of their opinions as to desirable intensities.

In relatively few instances has more artificial light been employed than the circumstances warrant. There is occasionally encountered a popular opinion that artificial light is used more largely than is necessary. The phrase "over illumination" appears to have found some place in popular parlance. The origin of this impression is to be found not in the use of too much artificial light, but rather in the glare of exposed light sources which are excessively bright and which create the impression of high illumination. Good illumination involves correct practice in respect to intensity, diffusion, direction, and color of light. When the artificial illumination is correctly designed as to diffusion and direction, there is no suggestion of over illumination. To talk of over illumination by artificial light is unreasonable, in view of the fact that intensities range from, say, a minimum of 0.01 foot-candle outdoors to a maximum of 5 foot-candles indoors, while sunlight as we employ it ranges from, say, 10 foot-candles indoors to a number of thousands of foot-candles outdoors. How then is it possible to speak of over illumination by artificial light, when the brightest artificial illumination is only, say, one-quarter of the least bright sunlight which is used for the same purpose within buildings?

Let us base our consideration firmly upon the fact the indiscriminate curtailment would involve reduction from lighting standards which are less than adequate.

WASTE VERSUS EXCESS

There is an important distinction between waste and excess in lighting. Waste has no compensations; it should be eliminated wherever found. Lamps left burning when no light is needed; unconsumed fuel in discarded ashes; unconsumed gases passing up the chimney—these are wastes.

Excess, on the other hand, is difficult to define, and there is always room for difference of opinion as to the line of demarcation between sufficiency and excess. Illumination which would have been considered excessive a few years ago is now accepted quite as a matter of course. This is not a question of style—activities are now more intensified. Speeding up all along the line is associated with higher levels of illumination, either as cause or effect. Therefore while we should condemn waste wherever it is found, "excess" should be examined carefully before a verdict is reached, lest more be lost than gained as a result of reduction below intensities mistakenly regarded as excessive.

OBJECTS OF CURTAILMENT

The objects to attain which lighting may be curtailed justifiably are principally:

Military advantage.

Release of generating capacity for more important work.

Coal saving.

Money saving.

Beneficial psychological effect.

Military Advantage.—In England and France lighting has been suppressed with a view to concealing cities and landmarks from enemy aviators. Thus far this phase of the problem has not influenced practice in this country. Lighting restrictions have served no direct military advantage.

Release of Generating Capacity.—Where there is a shortage of generating capacity, as has occurred in a few localities, the removal of the non-essential load for the purpose of releasing generating capacity for work contributing directly to the prosecution of the war and to the

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NOTE:—*Coal Data in this paper Confined to Electric Lighting.*

Properly a paper of this kind presented before the Illuminating Engineering Society ought to include all form of light. Practically, however, the time available for the preparation of this paper has been so short, that it has been necessary to confine attention to electric lighting. The principles which are emphasized apply equally as well to flame illuminants. The manner of their application, the conditions of use which affect and even govern their application, and the conclusions to be drawn are peculiar to each kind of lighting.

important needs of the public, is a valuable expedient. " Unnecessary "* lighting falls within this class.

Coal Saving.—A saving of coal which is not justifiable because uneconomical in ordinary times becomes entirely so when the supply is inadequate. Curtailment of " non-essentials," including unnecessary lighting, is in order. At such a time it is desirable to do this if the advantage of coal saved outweighs the disadvantage of curtailment.

Money Saving.—The value of artificial lighting is incommensurately greater than its cost to the public, and it is used rather too sparingly. From this point of view alone, more money ought to be spent on artificial lighting. A thrift campaign will touch many non-essentials and some essentials before general curtailment of artificial lighting becomes desirable on this score. Real economy, generally speaking, is not to be served by a reduction in artificial lighting.

" Psychological Effect."—The " psychological effect " which is said to be desirable may be any one of the following: it may remind people of the need for reducing light at home; it may remind people that we are at war and that economy is to be practiced in all directions; it may create the impression that large savings in coal are being effected.

The same qualities of artificial lighting which render it conspicuously successful as an advertising medium bring about attempts to curtail it with a view to advertising to the public the need for reduction of consumption of other commodities. Whether or not the effect upon the public of curtailment of advertising lighting is that which some people have anticipated is a question. If the " psychological effect " of extinguishing prominent electric signs prompts the public to save in coal as in other things, the result should be good. If it leads the public to believe that large coal savings are being accomplished through such curtailment, the result is not likely to be good. For best ultimate results our actions must be based upon facts and not upon erroneous impressions. In either event the " psychological effect " will be felt most strongly at the start, and will cease to operate conspicuously after the public shall have become accustomed to the new order of things.

METHODS OF LIGHTING CURTAILMENT

Various methods of reducing artificial lighting as a war measure have been proposed as follows:

1. Remove unnecessary lamps.
2. Extinguish all lamps when they are not needed.
3. Extinguish some of the lamps when possible.
4. Substitute smaller sizes of lamps.
5. Replace inefficient by efficient lamps.

Remove Unnecessary Lamps.—This should be done by all means. The power, the labor of attendants and the lamps themselves are needed elsewhere for important work.

Extinguish All Lamps When They Are Not Needed.—There is every reason for emphasizing the desirability of eliminating unnecessary use of light. Fuel administrators and lighting companies have urged this expedient very prominently. Bulletin V of the Committee on Coal Conservation of the Chamber of Commerce of the United States, entitled "Conservation in Use of Coal" (see Appendix) contains some excellent suggestions for curtailment of lighting.

Extinguish Some of the Lamps When Possible.—To have available a complete lighting equipment with lighting units of reasonable power to meet the requirements in a given installation is an excellent thing. Some of these may be extinguished for certain purposes without disadvantage. Thus, in a home, a room which is needed for reading purposes at certain times and is used at other times for purposes which do not require close application of the eyes, may be served by a reduced amount of illumination on the latter occasions. This plan is superior to that of replacing lamps of reasonable power with small lamps, making it impossible to get the full illumination when it is required.

Likewise, in small specialty shops, or in certain rooms of mercantile establishments, a part of the lighting system may be used when customers are not present and the full lighting may be turned on when customers enter.

Substitute Smaller Sizes of Lamps.—This is advisable in a few classes of service where lighting is now of ample intensity. In general, or as a wholesale proposition, it is inadvisable for the following reasons:

Present intensities of illumination are less than in expert opinion are desirable for the most economical ultimate results.

There is now a lamp shortage, and to dispense with moderate-sized lamps would result in the loss of many of them which would be a serious economic waste.

Smaller lamps are of slightly lower efficiency and are more fragile than are moderate-sized lamps. Fragility means shorter life in service. The extent to which this is the case is indicated in the following table:

Lamp rating in watts	Relative candle power produced per watt	Filament breakage in careful handling in laboratory after 1000 hours of burning per watt
100 (gas filled)	132	—
100 (vacuum)	107	0.4
75 (gas filled)	121	—
60 (vacuum)	102	0.4
50 (vacuum)	100	1.4
40 (vacuum)	99	1.4
25 (vacuum)	96	1.8
15 (vacuum)	90	3.7
10 (vacuum)	79	6.4

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*Necessity and luxury are relative terms. Lighting which is important may be dispensed with in a national emergency. That which seems least important is here classed as " unnecessary."

When using small lamps one is between the devil and the deep sea. If he cleans them in order to maintain them at the highest efficiency and avoid waste due to dirt, he is likely to break the fragile filaments. On the other hand, if to save the filaments he does not clean them, waste is incurred through dirt absorption. The moderate-sized lamps which are used more generally are more rugged, and do not place the user in this awkward predicament.

Replace Inefficient by Efficient Lamps.—With few exceptions, carbon and Gem lamps and open gas-flame burners ought to be eliminated and replaced by the more efficient Mazda and gas mantle lamps respectively. For the same energy a Mazda lamp will produce three times as much light as a carbon lamp, and a gas mantle lamp will produce five times as much light as an open-flame burner. The relatively inefficient carbon lamps and open-flame burners usually produce too little light for the purpose, and the full light of the more efficient illuminants which may be used to replace them is often desirable. Where it is not necessary, however, advantage may be taken of the substitution of the more efficient illuminants to reduce consumption below that of the carbon lamp or open-flame burner by using smaller size lamps of the efficient types.

OTHER MEANS OF SAVING FUEL

To arrive at suggestions for saving fuel used for lighting purposes without deleterious effect, one should consider the elements of inefficiency in lighting, and the possibility of eliminating them. Such a line of consideration brings the following to the fore.

Good Utilization of Light.—Selection of suitable reflectors or other lighting accessories may in some cases make it possible to provide equally good illumination while using smaller or fewer lamps.

Good Maintenance.—Dirt cuts down lighting efficiency markedly. Statistics are available to show that cleaning of lamps and lighting accessories have increased the useful illumination by as much as one-third. It is reasonable to state that the difference between good and poor maintenance of a lighting system will account for 20 per cent. of the total light.

Use of Good Reflecting Surfaces.—Good white paint or other good light reflecting surfaces conserve light materially. Sometimes a wall or side of a building may be whitewashed with the result that more daylight is reflected into an interior, thus reducing the use of artificial light.

Other measures which are attracting favorable consideration, but which are not within the scope of illuminating engineering, include the following:

Daylight Saving.—The adoption of summer daylight saving as now proposed is estimated to be capable of reducing the coal consumption of electric central station steam plants by 230,000 tons per annum for the entire country.[15] A suggestion to advance the period of activity by one hour the entire year round, which is now attracting considerable attention, is estimated to afford about the same saving to the public in lighting bills, but to result in a somewhat greater saving of coal on account of the more favorable load factor for power plants which would result in the winter months.

Utilization of Water Power.—It is estimated that only about one-tenth of the available water power of this country is developed. Most of the remainder is in the western states. Much of it is remote from centers of population. All will require time for development after legislative impediments shall be removed. It is clear, however, that tremendous reductions in coal consumption may be effected in the future thru further utilization of our water power resources.

Elimination of Small Power Plants.—The inherently lower efficiency of small plants, together with the less expert operation which in general they receive, is estimated to be responsible for the use of one-third more coal than necessary. This element of waste is even more serious in England than in this country, as is evidenced by a recent report (April 16, 1917) of the Coal Conservation Sub-Committee of the Reconstruction Committee,[16] in which, after pointing out that the average capacity of English generating plants is 5000 horsepower, it is stated that "The present coal consumption if used economically would produce at least three times the present amount of power."

DESIRABLE ADJUSTMENTS OF LIGHTING

The extent to which it is desirable to reduce artificial lighting depends upon the seriousness of the emergency which is to be met. The grave shortage of coal during the past few weeks has made necessary the reduction of a number of luxuries and some necessities. Artificial lighting has borne its full share of the necessary curtailment, and rather more than its full share of the attention of the public in general as a means of compensating for the fuel shortage.

The extent to which lighting should be adjusted in the present unusual circumstances will perhaps be better appreciated if artificial lighting is considered separately for the various principal kinds of service, which for the present purpose are classified as, street lighting, the lighting of public buildings, industrial lighting, protective lighting, commercial lighting, residence lighting, recreational lighting and advertising lighting. Adjustments may be effected in each class by altering the level of illumination intensities maintained, or by changing the extent of the lighting.

Street Lighting.—It is desired to differentiate between civic street lighting considered under this head, and display lighting for business purposes, sometimes called "white way" lighting. Civic street lighting provides safety against collisions, protection against criminals, reduces the amount of policing necessary on the streets and permits the public to go about after dark conveniently and without annoyance. It costs the public about $1.00 per capita per year. It is generally adjusted as to intensity with respect to extent of the traffic and the real estate development of the neighborhood. The development of the automobile has created a need for much more light in the streets in order to provide for safety against collision and crime. It is generally considered that the lighting of streets is inadequate. Of the total mileage of lighted streets only an insignificant proportion is lighted to such an extent as to make it advisable to curtail the lighting even in times of fuel shortage such as we are experiencing.

Abroad during 1915–16 extreme precautions were taken in the way of eliminating or concealing from above all street lamps. It developed, however, that the menace to the public from street accidents was much more serious than the menace from enemy airships.*

It is stated that from Aug. 1, 1914, to Jan. 31, 1915, in the metropolitan area of London during the hours of darkness 954 persons were killed in street accidents, and 137 were killed in airship raids. To the reduced street lighting is attributed a large part of the excess of street accidents. English technical literature makes it evident that during the past year official and public opinion has undergone considerable change on this question. Public lighting restrictions are less severe, and the former street lighting is being restored to some extent.

Street lighting should not be considered independently of sign lighting. In localities where the public congregates in large numbers at night, there are likely to be electric signs which add very materially to the street illumination. The extinction of these signs places entire dependence upon the street lighting system which alone sometimes proves inadequate. In certain portions of Times Square, New York City, not in the vicinity of any particular sign, the illumination of the street is five times as great when the signs are in operation as it is when sole dependence is placed upon the street lighting system.[12]

Lighting of Public Buildings.—Libraries are probably of greater reference value in time of war than in time of peace. The lighting of libraries is notoriously inadequate, and ought to be increased as well as improved. University and college buildings may offer some opportunity for diminished illumination by reason of the decreased number of students occasioned by the war. Schools, like libraries, are generally inadequately lighted. Federal and municipal buildings require the usual amount of light, to the end that public work may not be impeded.

Industrial Lighting.—Progressive manufacturers have devoted a good deal of attention in recent years to lighting. Good factory management requires liberal lighting, and good lighting. While statistics are difficult to obtain, yet it is generally believed by those who have devoted attention to the subject, that production is increased, shrinkage reduced and accidents avoided through adequate lighting.

Recent tests made in a machine shop of one of the large Chicago concerns under the direction of the Lighting Committee of the Commonwealth Edison Company showed from 8 to 27 per cent. increase in production when the lighting intensity was increased from 4 to 12 foot-candles. These figures cover eight different operations which averaged a 15 per cent. increase. For each intensity a carefully designed system with deep bowl steel reflectors was used, and every precaution was taken to insure fair results.[13]

As increased light promotes production, so diminished light reduces production. If to save coal, production must be curtailed, it is an interesting question if it is more economical to reduce the lighting and effect a small coal saving, or to reduce the heating and effect a larger coal saving, or to close the plant for a short time and effect a still larger coal saving. Whatever the answer may be in a particular plant, it will be found that but small coal saving may be effected by curtailing the lighting as compared with that which can be effected by other means.

Real economy in such case dictates the use of slightly more coal, if the coal is available, and permits a curtailment of the lighting only if the coal shortage is such as to make it necessary to accept a serious falling off in production. Many of the older industrial plants and most of the small factories are not adequately lighted. In time of war and labor shortage, when the utmost production from each worker must be had, industrial lighting should be increased rather than decreased.

Residence Lighting.—In some rooms which are used for social or recreational purposes, more light is used in some cases than esthetic or other considerations dictate. The greater number of rooms are underlighted. Modern life extends the hours of visual activity far into the night, imposing demands upon our visual organs which our forefathers never encountered. This greater demand, in combination with inadequacy and misuse of light, is transforming us into a bespectacled race. The menace of poor home lighting is particularly serious in the case of children, whose eyes, ophthalmologists tell us, are

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* The following is the record of motor vehicle accidents in the city of London:[11]

Total	Number of accidents Fatal	Non-fatal
1913	424	13,157
1914	493	14,638
1915	666	16,366
1916 to Oct. 31	509	11,827

more liable to permanent injury thru strain involved in near vision work under conditions of poor illumination than are the eyes of adults. The conclusion must be that considerable saving in lighting may be effected in the homes by greater diligence in extinguishing lamps at times when they are not needed, and by reduction of light in rooms which are not devoted to visual activities. Aside from this, the need in home lighting is for the use of more rather than less light. Ample light makes possible the use of diffusing safeguards which with less light would be discarded.

Protective Lighting.—In time of war, especially in a country which, like ours, harbors so many enemy aliens, the guarding of property which is important to the prosecution of the war and to the welfare of the people, is a necessity. The labor shortage makes it difficult to provide a sufficient number of guards for the purpose, and guard labor involves large expense. The effectiveness of a guard at night depends in large part upon his ability to see all parts of the area entrusted to his care. Artificial lighting is, therefore, a very important factor in the protection of property. It alone makes night guard duty effective. It makes effective guarding possible with fewer guards. It tends to deter from attempts at depredation as well as to make it possible for guards to discover any menace.

The numerous attempts at interference with our industries prior to recognition of a state of war by this country led to some increase in the extent of protective lighting. During the past few months the increase in protective lighting has been rapid. Notwithstanding this, many points of vital importance are either unprotected by artificial lighting or are insufficiently protected. An increase of a number of times in the amount of protective lighting is urgently needed.

Commercial Lighting.—Stores of the better class employ adequate illumination at night. In a few cases excessive illumination may be found. (Show windows are considered to be included under advertising lighting.) Offices are practically never overlighted, and upon the whole may be said to require for best work, and therefore for best economy, somewhat more light than is generally used.

Recreational Lighting.—The importance of recreation at all times is generally recognized. Several forms of recreation are considered to be practically indispensable. Nevertheless, in times of emergency, recreation certainly takes a place secondary to many other activities in which artificial light is employed. Theatres, churches, dance halls, etc., generally are not overlighted. (Signs of course are included under advertising lighting.) Saloons are said to employ more light than is needed.

Advertising Lighting.—Advertising is a necessary factor in commercial success. Among advertising methods the employment of artificial light holds an important place. There are perhaps fewer objections to the elimination or reduction of advertising lighting than there are to the elimination or reduction of most other classes of lighting, but curtailment of advertising lighting works damage to the business of those who utilize this form of advertisment just as would the curtailment of any other form of advertising. There are various degrees of importance of advertising lighting. All the complicated questions of priority are involved. The only measure of desirable curtailment of artificial lighting is the emergency which occasions the curtailment.

ESTIMATE OF PRACTICABLE CURTAILMENT

The author has prepared the following rough estimates of the manner in which artificial light is distributed among the several classes of service adopted as a classification for this purpose. There are no general statistics on this subject. Some fragmentary data and the opinions of several men engaged in the lighting business have been obtained. It is to be emphasized, however, that these figures should not be accepted as anything more than very roughly approximate.

Beside these figures showing approximate distribution of lighting among the several classes of service are figures representing the consensus of opinion of twenty qualified observers[14] as to the extent to which lighting in each class of service ought to be curtailed or increased in the present emergency. The values are probably reasonably indicative of expert opinion on this subject at the present time.

Adjustment of Illumination which According to Expert Opinion Ought to be Made from Standards Existing before the War in View of the War and the Fuel Shortage

Class of lighting service	Per cent. distribution	Desirable adjustments per cent.
Street	14	— 5
Public building	3	— 10
Industrial	19	+ 50
Protective	1	+200
Commercial	22	— 10
Residence	24	— 20
Recreational	7	— 40
Advertising	4	— 75
Miscellaneous	6	— 10
	100	Net — 3

In presenting an advance copy of this paper before the New York and Philadelphia meetings, the author stated that the consensus presented at that time included all opinions which had been received up to the time of going to press, and that opinions received later tended to make the assignment of net curtailment smaller than that shown in the advance copy. The net curtailment shown in the preliminary assignment was 7 per cent.* The present assignment, netting 2.9 per cent., includes all opinions which the author has received in response to his questionnaire. The conclusions stated in the advance copy based upon the 7 per cent. assignment are even more valid when the assignment has been made 3 per cent.

The total reduction in lighting indicated by the assignment in the foregoing consensus is 14.4 per cent. It is almost counter-balanced by an increase in lighting called for in industrial and protective lighting aggregating 11.5 per cent. of the whole. This leaves a net curtailment of 2.9 per cent. or say 3 per cent. It would appear to be equally the duty of the members of this Society to seek to bring about reduction in lighting where it can be accomplished without undue disadvantage and to seek to bring about increase in lighting where advantages can be gained. It is difficult to say which is the more important. In any event, the 3 per cent. net saving is the figure which should enter into our calculations of practicable lighting curtailment.

It will be recognized that both the extent of lighting and the level of illumination intensity in each class of lighting are involved in this survey. In protective lighting, for example, it is a more extensive application rather than higher intensity which is required. In industrial lighting, on the other hand, higher intensities are deemed advisable.

Desirable readjustment of artificial lighting to meet war conditions and to assist in meeting the coal shortage consists, therefore, in eliminating extravagant and unnecessary light, in eliminating the use of lighting for unnecessary periods, in reducing the intensity in a few places, in increasing the intensity in a few classes of lighting and in extending lighting in other classes of service.

It is important to compare with the foregoing table that which appears on page 385. This comparison shows that in the opinion of lighting experts, electric lighting which to attain most desirable standards ought to have been increased by 72 per cent. before the war, ought now to be decreased by 3 per cent.

COAL SAVING THRU CURTAILMENT OF ELECTRIC LIGHTING

It has been shown, page 389, that in the opinion of specialists lighting may be curtailed in certain classes of service to an aggregate of 14 per cent. of the total lighting; that in certain other classes of service lighting should be increased to an aggregate of 11 per cent.; and that there is therefore a net desirable curtailment of 3 per cent. which may be effected as an emergency measure in view of the war and the fuel shortage. If a proportional amount of coal saving be assumed, this would mean a reduction in coal consumption of 360,000 tons per annum.* This is the maximum extent to which it is believed that the best interests of the public require coal to be saved thru electric lighting curtailment. Such a saving compares with other possible annual savings as follows:

Total annual saving which must be accomplished.	50,000,000 tons[7]
Savings within the control of the public—	
Net saving thought desirable thru curtailment of electric lighting	360,000 tons[14]
Saving if each family decreases by one shovelful its daily use of coal	15,000,000 tons[17]
Saving by maintaining temperature of building interiors 3° lower, say 67° instead of 70° F.	10,000,000 tons[9]
Possible savings not within control of the general public—	
Saving by railroads thru practicable light firing of locomotives	7,000,000 tons[19]
Practicable savings requiring some time for consummation and not within the immediate control of the general public—	
By railroads thru electrification	40,000,000 tons[20]
Accomplished by Chicago, Milwaukee & St. Paul Railway thru electrification and utilization of water power on its Rocky Mountain Division	500,000 tons[21]
By substitution of central station power for private plants	13,000,000 tons[8]

Coal saving thru lighting curtailment can make only a small contribution to the total saving which must be effected. That small saving, however, should be made and to that end all means of reducing consumption for lighting which have been discussed favorably in this paper ought to be practiced. Yet with the utmost of patriotic action it is possible for those engaged in the lighting business and for the general public to accomplish only an insignificant part of the necessary saving thru such means. It is therefore not with any desire to distract attention from the need for effecting saving thru lighting curtailment, but rather in the hope of accomplishing greater savings otherwise that engineers must turn their own thoughts and the thoughts of the public toward other means of conserving coal. Among these, the possibilities thru changing the practice of heating buildings are especially important.

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* Assignment of opinions included in the advance copy of the paper was as follows:

Class of lighting service	Per cent. distribution	Desirable adjustments per cent.
Street	15	— 5
Public building	3	— 10
Industrial	18	+ 50
Protective	1	+200
Commercial	20	— 20
Residence	26	— 20
Recreational	7	+ 40
Advertising	5	— 80
Miscellaneous	5	— 10
	100	Net — 7

* Seven per cent. or 840,000 tons was estimated in the advance copy of this paper.

AN ESSENTIAL DIFFERENCE BETWEEN COAL SAVING THRU LIGHTING CURTAILMENT AND CERTAIN OTHER COAL SAVING MEASURES

A relatively small quantity of coal may be saved thru curtailment of electric lighting. This is accomplished at the expense of a certain amount of damage to business. Most of it will fall on display and advertising lighting. As a consequence, the business of those who depend upon this form of advertising will suffer. The remainder of practicable lighting curtailment will fall in other classes of service where its principal effect may be annoyance and inconvenience. In both cases the revenues of lighting companies and of manufacturers of lighting appliances will be reduced. The only savings in artificial lighting which may be accomplished without disadvantage to business are those effected thru the substitution of efficient for inefficient light sources, thru the use of good and efficient lighting equipment and thru good maintenance of lighting systems. There can be no question that these ought to be brought about, altho they are not included in lighting curtailment.

Savings of coal thru improved heating of buildings, thru the maintenance of somewhat lower temperatures in buildings, thru light firing of railway locomotives, thru the substitution of central station for private plant power, thru the electrification of railways, etc., are savings thru the elimination of waste and are comparable in this respect with savings in the lighting field which may be accomplished thru the substitution of efficient for inefficient light sources. They are in a different class from savings of coal effected thru lighting curtailment.

In view of this distinction and in view of the much greater coal savings which may be effected in other ways, it is to be hoped that the relative disadvantages of saving the very small amount of coal thru lighting curtailment and thru other means will be weighed most carefully.

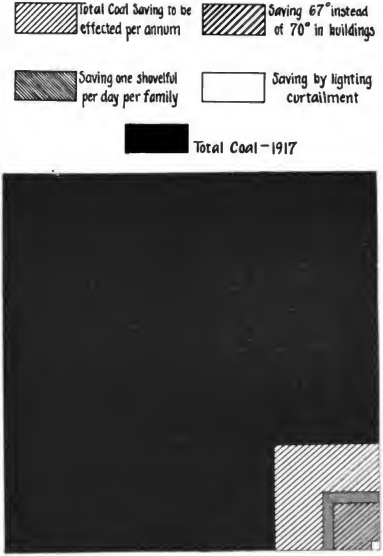

Fig. 2.—Savings in coal which it is practicable to effect thru curtailment of lighting and by some other methods.

CONCLUSIONS

It would appear that members of the Illuminating Engineering Society have two duties to perform in the lighting field in the present emergency: (1) They should promote the elimination of waste in lighting; (2) they should promote the use of more light in the industries. Because but little coal can be saved in lighting, it would appear to be incumbent upon them to be even more diligent in the elimination of extravagance and waste in order to accomplish their part and to make possible the use of more light where it is needed for the purpose of promoting industry. At the same time it would appear that we have a duty to make known the facts in regard to lighting conditions and the relation of artificial lighting to coal consumption as well as to urge upon authorities and public alike, the importance of adjusting artificial lighting so as to promote the best interests of the country in the present contingency.

General curtailment of lighting would be a menace. For the last eleven years the Illuminating Engineering Society has devoted a large part of its efforts to promoting good illumination. The research and investigation of its members on the effect of light upon the eye; the influence of its technical discussions upon design and installation of lighting appliances; its popular educational campaigns in the fundamentals of good lighting have resulted in the improvement of lighting practice especially in the more recent installations. A small beginning has been made toward approximating daylight characteristics in artificial lighting. The important feature of daylight which we seek to emulate is diffusion of light. Without this quality daylight intensity would be unbearable. In order that artificial light may be diffused an ample supply must be produced. If the quantity of light were reduced means for diffusing it would be discarded and it would be used in its raw or crude state. This would set back by ten years or so the development of the lighting art which has been in the interest of the public. It would do more, for in the interval much more brilliant light sources have been substituted for those of ten years ago. To remove light diffusing safeguards would leave these brilliant illuminants exposed.

In the author's judgment, general curtailment of lighting would result in damaging the eyesight and impairing the efficiency of our people. It would be wise only if the coal shortage should become so acute and distinct that the impairment to the human energy of the country would be preferable to the small amount of coal involved.

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3. Statistical Abstract, U. S. Dept. of Commerce, 1914.
4. Dr. Garfield before Senate Committee on Manufactures estimated January 1 to December 1, 1917, total coal output at about 575,000,000 tons. (*Coal Trade*, Jan. 2, 1918.)
5. Goodman and Jackson (*Proceedings A. I. E. E.*, Jan., 1918) estimate total consumption steam-driven electric central stations for 1917 at 20,000,000 net tons. More recent estimates by T. C. Martin and W. C. Anderson of the N. E. L. A. point to a somewhat larger figure. Fifty per cent. output added for private plants.
6. Author estimates that one-third central station electric power goes into production of light. Somewhat smaller proportion for private plants.
7. Bulletin V, Jan. 4, 1918, Committee on Coal Conservation, Chamber of Commerce of the U. S.
8. Goodman and Jackson (*Proceedings* A. I. E. E., Jan., 1918).
9. Computed for the author independently by E. F. Tweedy and E. D. Doyle that reduction from 70° to 67° will save about 10 per cent. of coal. Coal used for heating 110,000,000 tons —U. S. Geological Survey, 1915.
10. Assigned from estimates submitted by Messrs. F. C. Caldwell, J. R. Cravath, W. A. Durgin, C. L. Law, W. F. Little, M. Luckiesh, N. D. Macdonald, L. B. Marks, P. S. Millar, E. B. Rosa, C. H. Sharp, G. H. Stickney, F. A. Vaughn.
11. *Electrician*, March 2, 1917, p. 652.
12. Data by W. F. Little.
13. Investigation conducted by engineers of the Commonwealth Edison Company of Chicago in conjunction with proprietor of shop.
14. Distribution assigned from estimates by Messrs. J. R. Cravath, W. P. Hurley, W. F. Little, N. D. Macdonald, P. S. Millar, A. L. Powell, W. H. Rolinson, W. J. Serrill, C. H. Sharp, G. H. Stickney. Adjustment which ought to be made in view of the war and the fuel shortage assigned from opinions by these gentlemen and Messrs. W. C. Anderson, Louis Bell, W. A. Durgin, F. C. Caldwell, R. S. Hale, D. C. Jackson, C. L. Law, M. Luckiesh, L. B. Marks, T. C. Martin, R. F. Pierce, E. B. Rosa, A. J. Sweet F. A. Vaughn.
15. Samuel Insull, *Electrical Review*, Jan., 1918.
16. Leon Gaster, *Electrician*, Dec. 22, 1916, p. 393.
17. Statement of Fuel Administration published in lay press.
18. *Electrician*, Dec. 28, 1917, p. 504.
19. M. A. Daly, Fuel Supervisor Northern Pacific Railway, reported in lay press.
20. E. W. Rice, Lynn Section A. I. E. E., Feb. 2, 1918.
21. *Electrical World*, Jan. 5, 1918, p. 59.

APPENDIX

CONSERVATION IN USE OF COAL

COMMITTEE ON COAL CONSERVATION

Chamber of Commerce of the United States
Riggs Building, Washington, D. C.

Bulletin V.

SMALL SAVINGS THAT COUNT

To the Members of the Chamber of Commerce
of the United States:

The shortage of coal for every day of the ensuing year amounts to about 40 ounces or 2½ pounds for every man, woman and child in the United States. Great economies in the use of coal will be effected by the factories, the central heating, lighting and power plants and the railroads. But small savings must not be neglected. Some opportunity is presented to every person every day to save coal by reducing the consumption of heat, light or power. The responsibility for making these savings is widely diffused among millions of people. The aggregate importance of them is correspondingly great.

Every ounce of coal saved is an outright contribution to the nation's war-time need for fuel. Some persons may easily save their entire quota of 40 ounces each day. The following schedule suggests some of the means for saving small quantities of coal. These savings, in the aggregate, will set free thousands of tons of coal for the industries of the country, for the railroads, for the navy, and for the ships that carry our men and supplies to France.

Conserve Electric Light; electric current usually comes from coal. Consult your dealer as to the most economical types of lamps suitable to your conditions and fixtures. A 25-watt lamp used instead of a 40-watt lamp saves at least an ounce of coal every two hours.

Turn Lights Off When Not Needed; if a 25-watt lamp or an ordinary gas light is turned off, even for short intervals, the aggregate saving may easily be an ounce of coal a day for each lamp.

Discard Carbon Filament Lamps; substituting a 25-watt tungsten lamp for a 16-candlepower carbon filament lamp provides a better light and saves 2 or 3 ounces of coal every day.

Burn Gas in Mantles, Not in Flat-Flame Burners; the old fashioned flat-flame gas light burner uses more than twice as much gas as a mantle burner giving more light. Each mantle burner substituted for a flat-flame burner will save probably not less than an ounce of coal a day.

Use Substitute Fuels; many kinds of fuel are available to supplement the coal supply. The waste material, such as "hog chips" of lumber mills, as well as brush wood, broken boxes, corn cobs, etc., may be pressed into service.

Attend to the Lubrication of Machinery; a drop of oil will often save an ounce of coal. Careful attention to the lubrication of all working parts of machinery will save many pounds of coal in the day.

Do not Super-Heat Rooms; observing the thermometer and turning off radiators to hold the temperature below 70° reduces the load on the heating plant.

Conserve All Heat and Power; keep in mind that every loss of heat or power is a loss of coal. A leak in a steam connection and a super-heated office room are alike the cause of wasted coal. Keeping a heavy power unit in operation when a lighter one would carry the load wastes coal, and so does all unnecessary use of electric elevators in office buildings.

Use Weather Stripping and Storm Windows; a bit of weather stripping about the door and the use of storm windows in offices, schools and all buildings that are heated, will reduce the burden on the heating plant and make effective a daily saving of coal.

Discourage Electric Display Illumination; this use of coal is not absolutely necessary. The genius for advertising which originated this excellent method of display should find temporarily other means of expression. Eliminating or foregoing an electric sign may save tons of coal a year.

These methods of saving heat, light and power are not unfamiliar. Everyone, perhaps, will think of some effective means of saving which is not included in this list. The important idea to be impressed on every person is that a great need exists for saving coal and that even small savings must not be overlooked.

Saving coal is not always identical with economy to the person effecting the saving. It may be someone else's coal that is saved; or the time and expense required to effect the saving may offset the money advantage. Nevertheless, it is a patriotic duty now to save coal at any reasonable expenditure of time and material. And in the majority of cases, there will be a direct or indirect advantage to the person entitled to the credit for the saving.

A voluntary, universal response to the call for saving coal in the many small ways that present themselves every day, will insure the success of the great efforts at fuel retrenchment which are now being made in the industries and by central plants.

Committee on Coal Conservation of the
Chamber of Commerce of the United States,
By Ernest T. Trigg, *Chairman.*

Any member of the National Chamber that wishes to distribute copies of this bulletin can obtain them by addressing the General Secretary, Riggs Building, Washington, D. C. Coal dealers who supply small plants should be in a very advantageous position to distribute copies to their customers.

DISCUSSION

President G. H. Stickney: When the United States undertook the serious business of war, a new condition obtained whereupon war became the dominating effort of the nation, before which all other affairs must yield more or less.

Many activities in the pursuit of happiness which were commendable a year ago must now be discontinued or restricted, lest they interfere with our struggle for victory. Art may have to descend from its pedestal and many luxuries be dispensed with until the "monster" is conquered.

In this, lighting is no exception. On the other hand, it must be recognized that all lighting is not on a par. There are many applications in which the country's interest will permit of no curtailment, but may actually demand extension.

Light is an important factor in warfare as well as in manufacture, transportation and other activities in support of the war.

While the Illuminating Engineering Society is interested in developing the lighting art, it has recognized that this aim must be subordinated to the one essential of winning the war.

The Society has been particularly fortunate in finding opportunities of serving the Government efficiently, and in this connection is indebted to the National Committee on Gas and Electric Service.

Mr. Millar, as Chairman of the War Service Committee, has organized and directed some of the most important service which we have rendered. In fact, this meeting was arranged for the purpose of contributing to that service by patriotically bringing out valuable facts and opinions regarding the relation of lighting to the war problem of fuel conservation.

John W. Lieb: The committee which I have the honor to represent, the National Committee on Gas and Electric Service, is fortunate in having among the various national societies coöperating with it, the Illuminating Engineering Society, and I wish at this time to take the opportunity of expressing the appreciation of our Committee for the effective coöperation rendered by the Illuminating Engineering Society, and the readiness and enthusiasm with which the members of your Committee on War Service responded to the repeated calls which were made by various departments of the United States Government through our National Committee, and which were passed on to this Society.

The subject which has been presented in Mr. Millar's paper was one which was brought to the attention of the National Committee on Gas and Electric Service at a very early stage of its work. Soon after the organization of the Committee on Coal Production of the Council of National Defense, a number of communications were sent to that committee, calling attention to various phases of fuel conservation, and various ways in which waste could be eliminated, and economies in the use of coal undertaken. I wish to present one or two letters in that connection, and I do so for the purpose of showing the attitude which the public utility companies—the electric lighting companies—took on this general question, and more especially on the question of sign lighting, which was the phase of fuel conservation first brought forward.

The first reference appears in a letter which the National Committee directed to an inquirer who sent a communication to Washington. This letter bears the date of July 24, 1917. After the introduction, these statements appear:

> "This subject—(referring to the large amount of coal that was said to be wasted in electric signs)—has been discussed to some extent in the public press, and being a subject that makes visual appeal to a large number of people, it should be given very careful consideration. The prevalent public opinion, that these display signs of various kinds represent, thru the energy they consume, a very large amount of coal, is quite without foundation. Statistics obtained from a number of our large cities indicate that electric signs and special white-way lighting of all kinds represent combined a consumption

of electric currents, amounting in various cities, to from 0.3 per cent. to a maximum of 1 per cent. of the total output of the power houses, a fair average being probably 0.6 per cent.

"To eliminate the use of this display lighting would, however, result in a saving of coal in a lesser proportion, and the actual saving would probably be less than one-half of 1 per cent. The reason of this relatively small energy consumption and consequent saving is due to the fact that the lamps used are tungsten lamps of the very smallest sizes, consuming only 7½ to 10 watts each, or approximately 100 to 130 lamps to the kilowatt. It appears to the public, therefore, that coal is being consumed wastefully and money expended unnecessarily to a far greater extent than is actually the case.

"It is true, however, that the uninformed public, observing this resplendent display, may consider that it is inconsistent for the public authorities to urge economy and conservation of our resources while the attention of the people is nightly riveted to what appears to them to be a display of extravagance and waste.

"There are, however, other points of view which should be taken into consideration. The smaller electric sign in front of the individual store is an appealing form of advertising attraction to the small merchant, who finds it impracticable to make use of the columns of the daily press. Shutting off of display lighting would be a serious disadvantage to the small merchant.

"Again, in our large cities this 'white way' lighting of various kinds forms one of the attractions of our great centers of population, brings strangers and visitors to them, and constitutes a welcome diversion to the volunteer or recruit who may be awaiting his call for military service.

"It has been the experience abroad that cheerful surroundings and a certain amount of gayety have a very favorable effect on the convalescence of the wounded soldiers, while gloomy surroundings have a depressing and unfavorable effect. It is for this reason that our Allies have found it necessary, while prohibiting street illuminations and displays in order not to attract hostile air craft, to maintain theatres, moving picture shows and other forms of entertainment to help cheer up the soldier on leave of absence and make enjoyable his short stay in 'blighty.' It would appear, therefore, that the situation is one of psychology rather than of economy, one of impression than of notable waste.

"In making a decision, therefore, as to the wisdom or desirability of eliminating this 'white way' lighting, all of these points of view must be taken into account.

"If it should appear important to the national or municipal authorities in the public interest to eliminate this display lighting, I feel very sure that the lighting and power companies would coöperate in every practicable way toward this end. They would not allow the effect on the revenue that would result from cutting off this consumption to stand in the way of accomplishing an important public purpose if it should appear that, taking everything into consideration, it was important in the public interest to eliminate even the appearance of waste or extravagance."

I wish also to read resolutions, which were adopted by the National Committee on Gas and Electric Service, and filed with the Fuel Administrator, Dr. Garfield, under date of November 1, 1917, which I think clearly set forth the attitude of the central stations of the country toward this subject.

Whereas, Under the extraordinary conditions arising out of the state of war, the public is visually impressed by the apparent waste of fuel which it believes to be involved in the lighting of the electric display signs, so conspicuous a feature of the life of our larger cities, notwithstanding the fact that, even in the aggregate throughout the country, this service requires the consumption of an inconsiderable percentage of the total coal required for the operation of electric power plants generating electrical energy; and

Whereas, The continued use of such electric signs apparently renders more difficult of consummation the efforts being made by the national authorities to urge the public to conserve and economize in the consumption of all the necessaries of life and the elimination of all waste and extravagance, real and apparent, in the use of the commodities essential to our nation and its allies in the successful prosecution of the war; and

Whereas, Exterior display lighting of the different kinds is of varying degrees of necessity and importance to the general public and to the business communities in which it is operated, depending upon the immediate purpose which it serves; and

Whereas, If and when the national authorities decide that the time has arrived when it shall appear to them to be necessary in the national interest and for the purpose of impressing on the people the importance of avoiding all waste and extravagance, to call public attention to the necessity of practicing economy in the use of fuel in industries, in the factory and in the homes of the people, they should then issue a pronouncement to the people of the United States requesting them, under the supervision and direction of the proper State and municipal authorities, to limit the use and operation of advertising, billboard and display signs, exterior publicity lighting and special ornamental street lighting of every kind, to that which is important and necessary for the convenience and safety of the public and for the proper conduct of the various business and commercial enterprises in the respective communities, and to render effective their coöperation in this work, be it therefore,

Resolved, That the public utility companies thruout the United States thru their organizations, the National Committee on Gas and Electric Service, of the Council of National Defense, representing the gas companies—manufactured and natural gas—the electric light and power companies, the water works companies and the central steam heating companies thruout the country, pledge their hearty support and coöperation to the national authorities in carrying out any plan or regulation for the saving of fuel, gas, oil, or electricity which the national authorities in the public interest may consider it necessary to adopt, as a war measure.

In this question of the suppression or limitation of the use of electric signs, the public utility companies have been placed in a somewhat difficult position. On the one hand, it is undeniable that the central station companies had for years past made every effort to stimulate that appealing form of advertising—a form which was at the same time an advertisement for the customers, an advertisement for the central station company, and an advertisement for the general public. For the lighting companies to have indicated an attitude of indifference to the welfare of this class of business, which it had done so much to stimulate, would have been, from the standpoint of the sign customer and the sign manufacturer, an unfair and an unwarranted attitude. On the other hand, a disregard of the appeal that it was an obvious thing to do to place electric signs under limitation, would have placed the central station companies in the unpatriotic attitude of having a greater regard for the maintenance of revenues than for the national welfare. This difficult phase of the situation made it necessary, and I may say, desirable, for the central station companies to come out with such a pronouncement as has been read to you this evening, in order to go on record, that their purposes in this matter were entirely patriotic—that it was a national question for the national government to handle, and that the attitude of the companies was in no wise one of selfish interest, but was the broad one of a national purpose, which they were most anxious to serve.

Many times the question has been asked: "What actual coal saving has resulted from the 'lightless' nights?" In the communication which I read a moment ago the anticipated saving was stated on the assumption that all exterior illumination would be dispensed with. The actual saving which has been accomplished is very difficult of determination. In these times central stations must use coal of poor quality, resulting in variations in consumption from day to day ranging up to 10 and 15 per cent. Under these conditions the difficulty will be evident of locating a saving of say ½ per cent. due to elimination of sign lighting.

Referring to the recent five days of curtailed industry, it may be said that in general the reduction in coal consumption through the lesser use of light and power was of the order of 25 per cent. The reduction on Monday under the regulations of the Fuel Administration has approximated 35 per cent.

I wish to say, in closing, that the Illuminating Engineering Society, as well as every other phase of technical and professional engineering activity, has an important work to do, and I feel very sure that the Illuminating Engineering Society will continue, as it has in the past, to respond with enthusiasm to the call which is being constantly made to an increasing extent, by the national government for aid and assistance in solving some of these momentous problems which are now pressing upon it.

C. W. CUTLER: I have heard Mr. Millar's paper with much interest and can only add my approval to the main thesis, that artificial illumination has become indispensable for the increasing complexity of the night work, and granting that the ever growing complexity of life is inevitable, more light rather than less is needed in factories, printing offices and other places where fine work must be done under difficulties.

With regard to the streets, one would not wish to go back to the days I remember in New England, where the street lamps were lighted when the almanac declared that there was no moon, but I would take exception to the statement that street signs are an essential part of street lighting. Let me quote from a recent article on sign lighting:

> "The big value of illuminated signs to any community lies in their wonderful brightening, boosting, and cheering influence. Compare any two towns with and without these signs. The one is alive, while the other is dead."

This is quite true and any protest must seem reactionary, but let us substitute "asleep" or "resting" for "dead" and the conservative has at least a fair ground to stand on. One might as well raise one's voice against the profusion of the daily press, an equal embarrassment of riches, which grows by the needs it creates; yet there are some who feel that true philosophy and enjoyment of life are not furthered in these ways.

In general terms these may be taken as the feelings of a silent, perhaps a sleeping fraction of the community, tho not a dead one, based on two main points:

1. That exaggerations of all kinds are stimulations which lead to reactions of various kinds, chiefly nervous, which are apt to become abnormal, and

2. That the lure of the streets and public places is putting an end to what was once an asset of our country, the home life, the contentment with simpler pleasures.

These excesses, if they really are evils and not phases of social evolution, are inseparable from all material prosperity and must be accepted, but it does rest with you gentlemen to so lead and moderate the public demand that the esthetic and the hygienic ideals shall not be forgotten.

A great deal more might be said regarding the effects of light, perfect though it may be and simulating to the closest degree possible, in distribution and quantity, the daylight, under which the eye has evolved; but the eye has not been adapted to use during eighteen hours a day under the stimulation of working conditions, and although it may stand the strain, our nervous resistance seems less, and the first sign of fatigue is excessive irritability and what may seem to be increased efficiency, but which is in reality the beginning of exhaustion or at least of diminished resistance.

We are living, not only at this moment, but in this age, under a stress for which we have not yet become adapted, and much of the hysteria and well recognized nervous reactions called neuroses and psychoses are simply our reactions to our environment and the effect of the stimuli with which we are surrounded. Competition, which has made the night work necessary, accompanied by the sensory stimuli to the eye and ear, as well as to the palate, is blinding us to a true comprehension of our relations to our environment, and shortening our perspective dangerously.

I feel that this statement may be considered quite out of place in a discussion of an economic question, and I offer my apologies for taking your time, but even though the saving of light is not of great importance, as Mr. Millar has stated, as a matter of economy of resources, it may be of value as a means of saving energy and as the beginnings of the return to a simpler mode of life in which mankind will not be less happy.

The changes to which the present generation has had to adjust itself are marvelous and it is those who experience the transition who pay the price. Most that the increased flood of light has given us is in the highest degree beneficial, but it has quickened the pace and the pulse of life and there are some who will not keep up. I speak as a physician.

I have watched with much interest the careful way in which your Committee on Lighting Legislation has dealt with the difficult problems of *factory* and *school lighting*, and it is reassuring to know that these important questions are in such hands. It is the children and the working classes whose conditions have been most unfavorable in the past and it is good to think that the boon of light, under the efficient control of this Society, is making their difficult growth and work easier and safer, and it is self-evident that curtailment along these lines would be little short of criminal.

M. G. Lloyd: With thousands of people suffering from the cold and with the manufacture of munitions of war interrupted as they have been in recent weeks, I feel that any consideration of interference of business in connection with this matter must not be regarded as important. As a prominent representative of the central station industry has said to-night, that industry would probably not lay great stress upon this phase of the question.

In trying to save fuel, however, the human eye ought not to be sacrificed. Suffering from cold is usually temporary and soon forgotten, but if the eye meets with a deformity it will probably never become normal again, and we know that the eyes, especially those of children, are likely to become deformed through the strain brought about by insufficient illumination.

When we consider the use of electric light in advertising, however, the question of impairment of vision is not usually involved. Most of us will agree that it is justifiable to temporarily discontinue this use of electric current in the interest of saving fuel. It does seem, however, like saving at the spigot while wasting at the bunghole. Wherever I go I am impressed with the waste of fuel for heating purposes. When riding in railroad trains the cars are frequently overheated. In visiting the apartments of my friends I find them overheated. We are meeting in an overheated room to-night. The thermometer on the wall indicates 74° which we can probably all agree is too high for either health or comfort. Not only are residences and other buildings overheated, but coal is used very inefficiently in them. Much coal passes through the furnaces without being consumed and the heat actually developed is used inefficiently.

In industrial plants we have a condition which is probably not quite so bad, but which is in dire need of improvement. Every mechanical engineer who has looked into the proposition knows that the average power plant is not operated efficiently and does not operate with the economy of fuel which engineers know how to obtain. An exception to this statement should probably be made in the case of the power plants of the big utility companies and a few power plants of industrial concerns. Many private power plants, however, are open to severe indictment on this score, as brought out by Mr. Myers in his recent article.* He and other engineers who have specialized on this subject do not hesitate to make the statement that a quarter, or perhaps a third, of the fuel used in the average power plant to-day could be saved if it were operated to the best advantage and as our best engineers know how to operate it. He mentioned one big steel plant where by suitable management 40,000 tons of coal could be saved annually. When we consider the total consumption of coal in the industrial power plants of the country, if the same ratio would obtain it means that we could save more than enough coal to make up the estimated shortage. To put it in other words, coal representing the capacity of 1,500,000 coal cars could be saved annually if the fuel were used with an efficiency which we know how to obtain.

It seems very evident that while saving at the spigot we should also save at the bunghole. I should like to see the Fuel Administration conduct a campaign along the same lines as that of the Food Administration, and bring home to every power-plant operator and to every citizen who operates a furnace on his premises the necessity of making the best use of the fuel which he consumes. There have been recommendations for use of weather stripping, storm-windows, etc., and we have probably all heard the suggestion with respect to saving a shovelful of coal per day, but such suggestions have not been driven home to the people as have been the admonitions of the Food Administration. If they were I think they might be much more effective. What we need, however, is not merely an admonition to save a shovelful of coal, but people must be told how to save that shovelful, and then we might expect them to get some results.

In the paper by Goodman and Jackson which the author has referred to, the statement was made that the coal being received by the power plants for consumption is not of as good quality as that received previous to the war. From my own observation I should say that the same is true of the coal now being used for other purposes. Residents in my own neighborhood have had coal delivered to them of such a quality that it was impossible to burn it in an ordinary furnace. In some cases it was nothing but dust or slack. In other cases there was a large proportion of slate or other foreign matter in it. The coal operators have frequently been reported to have said, and I have seen the statement made by the Secretary of the Coal Operators' Association, that the difficulty in this winter's situation has not been at the coal mines. The miners have been able to produce enough coal, but the coal could not be transported to the consumer. Lack of transportation facilities has been the principal difficulty and the source of the break-down.

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* D. M. Myers, *Journal of the A. S. M. E.*, Vol. 39, p. 901 (Nov., 1917), "Preventable Waste of Coal in U. S."

If this is true there is no excuse for shipping such poor grades of coal around the country and congesting the railroad facilities which ought to be better employed than by sending material to the consumer that cannot be burned. If some control were exercised by the Fuel Administration or by some other authority over the grade of coal that was shipped, undoubtedly a good part of the actual shortage could be eliminated. There might be an excuse for poor quality in coal if poor quality were essential to getting sufficient coal out of the mine, but with the mines able to produce more coal than can be transported I cannot see that there is any excuse for shipping the lowest grades of coal. It looks like a case of pure profiteering.

Goodman and Jackson estimated that the increased consumption due to poor quality was 10 per cent. Let us suppose that this applies to the entire coal output of the country. Using the figures given in the paper, this gives an additional consumption of 64,000,000 tons, which is more than the estimated shortage. Here then seems to be another point where a decided improvement could be made. If this vast waste on a large scale could be eliminated, the little saving that is accomplished by cutting down the amount of electric light would be entirely unnecessary.

Frank W. Smith: I hope it will be possible, through the medium of this Society and other proper channels, to give this presentation wide publicity. I was interested in Mr. Lieb's statement as to the New York Fuel Administrator's activities in the matter of coal conservation. The local gas and electric lighting companies were early called into conference with the State Fuel Administrator, and the coöperation of the companies was asked in the matter of suggested methods for the saving of fuel. Suggestions were made by the sub-committee appointed from the representatives of the local companies, that included a number of the suggestions set forth in Mr. Millar's paper.

The "lightless nights" together with the restrictions on window lighting, etc., were decided upon by the Fuel Administrator largely, I think, from the psychological point of view. At the request of the local administrator, the gas and electric lighting companies sent to their consumers, 1,700,000 in number, a communication pointing out the necessity of economy in the use of light, and attracting attention to other methods of saving, several of which are mentioned in Mr. Millar's paper. This card was printed and circulated by the companies at their own expense. The suggestions included the following: burn fewer lights—turn lights off when not needed—burn gas in mantles, not in flat-flame burners—maintain a temperature not exceeding 68°, etc.

There is an important item of which brief mention is made in the paper, that is, the question of the use of inefficient incandescent lamps. It is important to point out that of the 145,000,000 lamps sold in the United States, during 1916, more than 16 per cent. were of the carbon and Gem type. A very material saving in fuel would result from the substitution of more efficient lamps. Some central station companies, although but few, are still using the carbon type of lamp. The Lamp Committee of the National Electric Light Association has addressed itself to this subject during the past year and has in preparation further publicity on the subject.

Louis Bell: We must approach this question with the realization that we are facing a great national crisis—by far the greatest in our history. We are in the war of the ages—to stay in it until it is won—and we have got to make every move, to make every sacrifice, without whimpering, until that end is attained. Now, in this matter of the saving of light, I am sure every man in this room, engineer or representative of a central station, will do all he can to see that the use of light is economized, first, last, and always, so far as it is important for the saving of fuel, and so far as that saving does not interfere with his country's efficiency. Mr. Millar has shown us, with admirable clearness, how petty and small and silly some of the attempts at curtailment look. They are not the real thing. They are only camouflage of the most foolish kind. A little can be saved here, a few tons here, a few tons there, but nothing important as yet. The time may come when we shall have to save light for the sake of giving power for making munitions. When that time comes, we will give up the light, and turn the power into motors, and do it thankfully. The main thing is efficiency, right now, here and always.

What our Fuel Administration should do is to drive hard at the things that have been mentioned here—at the unnecessary wastes—at the wastes which are unnecessary in each individual home and at the wastes which are unnecessary and inexcusable, in the keeping up of business which has nothing whatever to do with driving forward to our great end. An eminent friend of mine, a chemical engineer, made a careful study a few years ago, as to the amount of fuel which is absolutely wasted by inefficient and useless combustion—wasted in the stove or the furnace; and from a very thorough and exhaustive sampling of contents of ash-cans, he made out that the waste of fuel, through absolutely ineffective combustion, through foolish extravagance, in inefficient heating apparatus, amounted to more than 20 per cent. That is more than all the savings we have got to make, and that waste occurs every day in ranges and furnaces all over the country. Now if you stop to think what the average range and furnace takes in the matter of fuel, you will very easily reckon that the saving which could be made simply by decent and economic use of the fuel, which we now throw away, would be more than enough to light every house that has to be lighted in this country. The waste in the actual average household per day is enough if burnt under the boilers of a central station to take care of the lighting of that house, and probably another besides. And so, what we wish our Fuel Administration would do, before it turns to the central stations, to ask them to curtail the output, or simultaneously with that demand—for we are willing to take our medicine with the rest—is that it should get after the evident and clear waste.

The central stations of the country, which are willing to bear their burdens manfully, are all regulated industries. Their prices and their manners and morals are strictly under governmental control, and I think that they have, therefore, a right to ask that the government should take other things under its control before it puts the screws on those who are willing to stand by it. That is the only complaint, I think, that the central station industry has to make. These are times when the utmost efforts of the government should be spent in suppressing those who are wastefully and wilfully throwing away the resources of the country and striving to make personal profit out of the necessities of a national crisis.

It was the head of a large corporation doing government work, who only yesterday responded to a Senator of the United States, when he was faced with the $6,000,000 profit that he expected to make, "Oh well, one can't run a corporation on patriotism." Well, what I want to impress here, and I believe every man in this room will agree with me, is that if the time comes for us to make answer, it will be, *"In time of need, we will!"*

Wm. A. Durgin: Isn't this entire question of curtailing the use of light simply one more case of the obvious expedient? Of the three necessities, heat, power and light, rooted directly in our lamentably diminished coal pile, but one, *light,* is visible. To the legislator or administrator caught unprepared in a crisis and under the American compulsion to do something quickly, restriction of the visible consumer no doubt appears the obvious first step.

Two per cent. of the fuel consumed is utilized largely in the most efficient heat transforming devices our engineers have been able to develop and under the direct supervision of fuel consumption experts. The 30 per cent. consumed principally in the haphazard heating contraptions designed by foundrymen, and under the cursory attention of irritated householders, irresponsible janitors, or itinerant servants. Competent men believe that a full one-third of that 30 per cent., 10 per cent. of our entire coal consumption, can be saved by lower temperature levels, more intelligent firing, and better efficiency of heating plants. Cutting the enthusiast's estimate in half, taking 5 per cent. as an attainable saving, isn't that worthy the concentration of all our best effort, the application of all our fuel commission's abilities?

At present with every desire to serve in this crisis, where can we get intelligent direction? How many of you householders know where to obtain reliable advice on simple changes in your heating plants which will enable you to save one-sixth of your consumption? I am not speaking of complex changes such as grates, ash-pits, and other ideal arrangements, but rather of the small points; the best cement for leaks in casings, the most easily applied lagging for pipes, or data from trials of various schemes of damper manipulation in houses like your own. Where can we buy cheap humidifying apparatus which shall make 62° or 63° as comfortable as 72° or 73° was? Presentation of points like these over and over again in every possible form of publicity will effect conservation out of all proportion to that resulting from substitution of 25- for 40-watt lamps.

In our ship yards, in our munitions plants, in the manufacture of necessities, the urge is for greater and still greater output. Higher intensities of lighting have been shown dispassionately and without prejudice to give a notable increase at a negligible cost with the same men and the same machines. And yet our attention is directed to the fact that the substitution of a 25- for a 40-watt lamp will save half an ounce of coal in one hour—that amounts to nearly a ton in a hundred years! Let us lighting men offer our services to our Government then, not for curtailing a non-existent luxury, but rather for applying better light and more light to winning this war—for utilizing light as a real weapon for victory.

W. D'A. Ryan: We are urged to economize in the use of light mainly for two reason: to save coal and for psychological effects, while the actual coal saving made possible by the extinction of electric signs is small in comparison with practical savings in other directions: nevertheless it is our duty to economize wherever possible in order to assist in the successful prosecution of the war.

I am particularly interested in the statement that the average estimate of thirteen engineers engaged in lighting work indicates that the present standard of illumination should be raised approximately 73 per cent. in order to conform to their ideas as to desirable intensities. This is certainly very conservative. It is my personal opinion that both industrial and street lighting intensities could readily be increased from 100 to 200 per cent. with marked advantages to all concerned.

At the present time, manufacturers and industrial workers are being educated, under forced draft, so to speak, in the use of more and better light and as a result I believe we will find that say five years after the close of the war industrial lighting in this country will be at least 150 per cent. higher intensity than at the beginning of the war.

I recently had occasion to compare some of the modern lighting installations with lighting recommendations which we made in the years 1901, 1902, 1903 and 1904. These included machine shops, textile mills and manufacturing plants in general, lighted mainly with arc lamps, concentric diffusers and concentrating mirror reflectors in high bays, which anticipated the present semi-indirect and direct lighting systems. It was interesting to note that ¾ watt per square foot was the average energy recommended for advanced lighting in the period mentioned. This figure has remained constant, but the foot-candle illumination to-day will run three or four times as high, showing that the increase in efficiency of lighting units and improved reflectoring has been fully utilized without compromising on the power consumed. A general increase to 1¼ or even to 1½ watts per square foot with present unit efficiencies is absolutely justified and should not be regarded as reaching a point of extravagance.

As Mr. Millar points out—street lighting generally is inadequate and only an insignificant proportion of the streets are lighted to such an extent as to make it advisable to curtail lighting even in the times of fuel shortage. It is just as important to keep our principal streets well illuminated for police protection and the minimizing of accidents as it is to employ protective flood lighting for industrial plants. An eastern city recently reduced its so-called white way street illumination in addition to cutting off the signs, for three nights, and crime and nuisance had increased so much that it was necessary to restore the regular street lighting service. I feel that it would be unfortunate if it becomes necessary to make further curtailment of street lighting, especially in the case of water power operated plants where there is sufficient energy available to take care of increased manufacturing demands.

W. H. ROLINSON: I am heartily in sympathy with all of the statements made by the author of the paper. I believe the paper should have publicity. There are a good many among us who can give this paper national publicity and I think it would be well if they would consider seriously the propriety of making such distribution.

W. J. HAMMER: Dr. Lloyd brought up a point which struck me very forcibly and that was the necessity of stimulating the saving of coal in our homes as is done in the methods of food conservation employed by the Food Administration.

The facts should be strongly brought home to the masses, that they should use their fires more intelligently and efficiently, shut off or bank their fires when not needed, prevent escape of heat and keep down the temperature of their overheated rooms; they should also turn off unnecessary lights and where practicable using small units of light, they would thus enormously assist in that conservation of coal which is of such paramount importance at the present time.

NORMAN MACBETH: I feel as Dr. Lloyd stated that the effectiveness of these conservation bulletins depends upon the extent to which they reach and are given attention by the individual. From the standpoint of the individual householder certainly very much greater coal savings can be effected along the line of conservation of heat with weather stripping, storm windows, elimination of excess radiation, and the maintenance of lower temperatures generally, rather than thru savings of light, even to the extent of the hardship of going without light altogether.

The coal that would be saved in my home thru reduction or elimination of lighting service is certainly not the kind of coal that could be used in a house-heating boiler. If a saving of one shovelful of coal per day per household will result in a total annual saving of 15,000,000 tons, and the saving which must be accomplished is 50,000,000 tons, I estimate my saving on the basis of 150,000,000 tons. This saving was effected generally in three ways. The steam mains in the basement were bare and painted black; on the advice of the consulting heating engineer that by properly heating the basement you could more easily warm the rest of the house. I reduced the radiation from this piping with sectional asbestos covering which I put on at a slight expense and which has resulted in the reduction of coal consumption of at least 25 per cent. Then, in one room which was not used and in two bedrooms, the radiators were turned off. Closer attention was also given to damper regulations and the maintenance of a temperature not exceeding 68° in those rooms where the radiators were in use. By the use of heavier underwear we can easily get along with very much lower temperatures than are used in most homes. It seems to me unfortunate that the Chamber of Commerce bulletins gave so little attention to these important means of coal conservation in comparison to the importance attributed to saving by a reduction in the use of light.

A great deal of attention has also been given to curtailment of display lighting, a large part of which, if not all, is a form of advertising. There can be no question raised at this date that advertising electrically justifies its cost. If the stand is taken, however, that any form of advertising which results in an expenditure of fuel should be curtailed, then I believe that attention should also be given to the display advertising in magazines and newspapers, a comparatively few pages of which are exclusively editorial. A single saving of 15 to 30 minutes in the running of a large newspaper or magazine press once a month would save sufficient fuel to light the average house for an entire month. The curtailing of large display advertising in the newspapers and magazines would more than offset the energy required for the electric signs of small merchants who cannot afford to advertise in the newspapers.

Mr. Millar had an exceedingly difficult subject to handle that it might not appear that his paper was merely a protest against interference of the business of the central station. The point should not be overlooked, however, that there are many thousand people who are conscientiously curtailing the use of light and believe that they are thereby doing their best in this conservation of fuel movement. Light should not be used extravagantly but, as stated above, it is very easy in approaching this subject from the heating end, to effect a saving many times greater than would result with a 100 per cent. saving in light.

Wm. J. Serrill: In reading Mr. Millar's very interesting and valuable paper, I have been struck with the wide difference between the estimates made by the experts he consulted, as to the amount of lighting that is needed in normal times, as compared with their estimates of what is needed in war times. These estimates place the proper amount of lighting in normal times at 73 per cent. higher than at present, while in war times they place it at 3 per cent. lower than at present. I am wondering whether the estimators in arriving at the latter figure, were not influenced by the present extreme condition of coal shortage. When these estimates were made, the coal shortage in the country was at its height. If it were believed that such a condition were to continue thruout the war, of course, a 3 per cent. decrease in fighting would not be unreasonable. But no one believes that such a coal shortage will continue, or will even repeat itself next winter. Therefore, if this table is intended to represent what should be the reduction below present lighting thruout the period of the war, I question whether there should really be any decrease whatever.

I have some sympathy with Dr. Cutler's remarks about white way lighting. While I believe that white way lighting is desirable and of advantage to any city, yet I wish it could be made more artistic than it generally is. The enormous signs that are needed in order to produce the grotesque effects aimed at are a defacement to the buildings on which they are erected, during daylight, and at night the effect is generally far from artistic. The development of flood lighting on a commercial scale permits of a very artistic illumination of the facades of buildings. It would be interesting to see a section of one of New York's principal thorofares treated with a flood of light in such a way as to make the most beautiful effect by night, and to produce the least possible defacement of the thorofare by day.

It will be noticed that Mr. Millar has confined his paper to electric-lighting. He has told me that the time at his disposal in the preparation of the paper was too short for him adequately to consider gas lighting. As gas lighting is largely confined to residences and to the interiors of stores and industrial establishments, it is not materially affected by the rulings of the Fuel Administration, and consequently, there is little impropriety in omitting it from the discussion. Roughly speaking, about 4,000,000 tons of coal per year are consumed in gas lighting.

Wm. LeRoy Robertson: I have had the pleasure of making a study of the effect that "daylight saving" will have on the electric lighting in Philadelphia, and I might say that if the clock is advanced one hour, the net saving in the lighting load alone will be about 6 per cent.

If a curtailment in electric lighting of 3 per cent. will save 340,000 tons of coal a year, as pointed out in Mr. Millar's paper, and assuming that the effect of "daylight saving" in Philadelphia is representative of the effect thruout the country, then the 6 per cent. gain by "daylight saving" will save an additional 680,000 tons a year for all electric lighting. This is based, however, on adopting "daylight saving" the year around; if adopted for six summer months only, then less than half of this amount, or about 270,000 tons would be saved, since lighting loads are not as large in summer as in winter.

Another important point relative to the effect of "daylight saving" is the reduction of the peak load on the electric light plant to the extent of probably 15 per cent. at least. This reduction will occur only should "daylight saving" exist during the winter months. This means the liberation of an equal percentage of plant capacity, which will be immediately available all over the country for industrial power loads, which during war times, is a valuable governmental consideration. To obtain such capacity by erecting new plant equipment requires considerable time and consequently involves serious delay when considering governmental work.

W. H. GARTLEY: In talking about the educational idea—educating the people—I was present at a conference in which Dr. Garfield made some statements in the earlier part of his tenure of office, and when the question of curtailment of display electric light sign lighting was in his mind, the question arose whether it would not be a good thing to reduce the amount, because, as he said, of the psychological effect. Dr. Garfield at that time had an idea that the amount of coal that was used in display lighting was larger than he afterward found it to be, on the statement of men who were at least as reliably informed as anyone could be; and his predecessor, Mr. Peabody, also made the statement before, that there was going to be a very large amount of saving due to the curtailment of sign lighting. At that time, the men who were present and were acquainted with the electric light field, made an estimate of about how much that would amount to per family per year. It was something like 4 pounds of coal to each family, if all the display sign lighting was eliminated. Then, I think afterward they rather increased that perhaps 50 per cent. But the psychological effect was that a great many people who thought they knew, had to modify their views as to what a tremendous amount of energy was used in sign lighting. They did not realize that these bulbs were very small lights. My thought was in asking Mr. Millar whether there had anything come up in New York as to the result of this sign lighting. New York City has it in accentuated form. The fact of the matter is that this severe winter that we have gone through has apparently brought home to a very large number of people who have been living in the cities, the necessity of reducing the expenditure for lighting, and from the data that we have in connection with the gas business, it appears evident that they found some means of doing it.

P. S. MILLAR (In reply): The paper has served one of its purposes in that the discussion which it has elicited has covered the subject quite thoroughly. Among those who have participated there is practical unanimity to the effect that we should all coöperate to save coal where practicable through the elimination of waste in lighting, and possibly, if the emergency warrants, through curtailment of lighting. It is agreed, however, that our utmost efforts will effect only a very small saving in coal. The country must look elsewhere for the larger savings in coal which have to be accomplished. The representative character and diversified view-points of the men who have contributed to this discussion bear testimony to the validity of this conclusion.

There was some adverse comment on Bulletin No. 5 of the Committee on Coal Conservation of the Chamber of Commerce of the United States which is appended to the paper. This Bulletin is included because it points out five ways in which coal can be saved through attention to artificial lighting practice. We are all in accord in our desire to effect such savings. The Bulletin can be made useful in this effort. I fully agree with criticisms of the Bulletin on the score that it devotes only two paragraphs to saving coal through attention to building heating practice, where large savings can be effected, while devoting five paragraphs to lighting where but small coal savings are possible. We desire to join with the Chamber of Commerce Committee in urging elimination of waste through lighting, while seeking to place various forms of waste of coal in their proper perspective, to the end that the largest savings may be effected as a result of directing effort into channels of greatest potential saving.

Mr. Gartley has asked for information on the psychological effect of electric sign extinction in New York City. On this point I have nothing but my personal opinion which is worth no more than that of any other observer. It is my opinion that the effect of occasional extinction has been good. It is proper and helpful to remind the people that we are at war, and that their efforts must be directed toward sober achievement. I have understood, however, that the purpose of sign extinction has been to save coal and not to accomplish any psychological effect. As a coal-saving measure I have seen the statement attributed to the Fuel Administration that the extinction of all sign lighting in the country two nights per week in the course of a year is expected to reduce the consumption of coal by about 250,000 tons.

Some comments have indicated that the paper shows little respect for small savings. I do not want to create that impression. The public, however, has gained the impression that large coal savings are to be effected through lighting curtailment. The newspapers foster this idea. As recently as the first week of January, the Fuel Administration was responsible for the statement that " there is an enormous waste of coal due to extravagant and reckless use of electric lighting." The amount of attention devoted to coal saving through lighting curtailment by the Fuel Administration, the public press and the public in general, is in my judgment out of all proportion to its importance as a coal-saving measure. It has seemed to me therefore important to emphasize the fact that the saving of coal through curtailment of lighting is relatively insignificant. In devoting an undue proportion of effort toward lighting curtailment, there is danger of neglecting to accomplish much larger savings in other directions.

For the many favorable criticisms upon this paper and for the appreciative comments of a number of the speakers I extend my thanks.

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WAR CONSERVATION OF POWER AND LIGHT

By CHARLES E. STUART

Chief of Power and Light Division, Fuel Administration, United States

GENERAL plans have been laid out for the conservation of light and power by the Bureau of Conservation of the United States Fuel Administration, of which Mr. P. B. Noyes is Director, and these plans will be carried out by the Power and Light Division. They will be developed under the following subdivisions:

1. Elimination of uneconomical isolated plants.
2. The application of the Skip-stop to railways and the regulation of car heating and lighting.
3. Economy in utilization of power and light in factories.
4. Utilization of excess water power and interconnection of power systems.
5. Limiting the production of power to the most efficient plants available.
6. Economy in the Refrigerating and Ice Manufacturing Industry.

A brief statement with respect to each of these subdivisions is developed below.

The plans will be carried out thru the coöperation of the following:

First.—A force of engineers organized and stationed with the Fuel Administration at Washington.

Second.—The Engineering Department of the United States Geological Survey.

Third.—The Power Division of the Council of National Defense.

Fourth.—A State Fuel Engineer attached to the office of the State Fuel Administrator, to supervise the activities in his State.

Fifth.—The Public Service Commissions and State regulatory bodies.

Sixth.—The Chambers of Commerce and similar representative business bodies.

Seventh.—Volunteer engineers located thruout the country.

The following gives the scope of the subdivisions:

1. ELIMINATION OF UNECONOMICAL ISOLATED PLANTS

The individualistic way in which fuel is now consumed in cities is not efficient. A ton of coal burned in a large central station will produce at least four times as much electric power as if burned in the average small plant, and if centralized burning could be introduced to a greater extent, the amount of fuel required could be largely reduced without reducing in any way the ultimate production of light and power.

It is frequently the case that in buildings where electric plants are located and where exhaust steam is utilized in the heating of the building and in furnishing hot-water requirements, such buildings cannot adopt central-station service without a loss of money and no saving in fuel would result.

As a rule it may be stated that where no extensive heating system is operated in conjunction with the generating plant, such a plant can purchase power at a great fuel saving and with a possible reduction in power cost. In other cases it would be more economical, from the viewpoint of fuel saving, to utilize central-station service in conjunction with isolated electric plants.

It is the duty of the Fuel Administration to devise means for securing a curtailment in the use of fuel in ways which will impose a minimum of hardship. It is believed that there are many plants not only in New York, but thruout the entire country, which could, at least temporarily, shut down their own electrical machinery and purchase power from others at a financial advantage to both parties and with a considerable saving in fuel.

The Fuel Administration believes that if even a comparatively small proportion of the plants thruout the country which could save fuel in this way at a profit to themselves would do so, it would prove a tremendous help in meeting the fuel situation with which the country is confronted, and in winning the war.

While it may appear that the interests of the central station are being benefited to a large degree, such is not of necessity the case. In some cases, central stations may be shut down. In any event any connection between a central station and a building or a manufacturing plant that is affected, will, of necessity, be for the period of the war only or thru the period where the coal situation is critical. The machinery of the isolated plant can be readily preserved thru this period of necessity. Under these circumstances the heavy expense attendant upon the making of the connection by the central station may completely or even more than offset any profit which could be expected of such a load thru a short period.

2. THE APPLICATION OF THE "SKIP-STOP" TO RAILWAYS AND THE REGULATION OF CAR HEATING AND LIGHTING

One of the most promising methods by which we are securing economy in the use of fuel thruout the country, is by the introduction of the "Skip-stop" system on the electric railways of the various cities.

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With the present practice of having cars stop on signal at any street corner, there are usually from 12 to 14 stopping points per mile. With the Skip-stop system, properly applied, these are reduced to not more than 8 per mile in the business districts, 6 per mile in residence districts, or 4 per mile in the open country. With the number of stopping points decreased in this way, a saving of from 10 to 15 per cent. can ordinarily be effected in the power (and hence in the fuel) required, while at the same time the average speed of the cars is increased (without any increase in the maximum speed) and the service thus improved. Since this measure secures economy in fuel not only without handicapping the service, but with an actual improvement, it is obviously an extremely desirable type of conservation measure.

Our plan is to secure the adoption of the system by voluntary coöperation between the railway companies and the various municipal authorities or state commissions and to bring about this coöperation thru the Federal Fuel Administrators for the several states. These administrators are all men of influence in their communities and so far we have found in every case that a request from the State Administrator to the proper authorities was all that was necessary to secure permission for the introduction of the system as a conservation measure during the war. With permission thus provided for, the railway companies have all been glad to adopt the plan.

Thru our efforts, thru the independent efforts of various local administrators, or thru the efforts of certain railway companies themselves, the Skip-stop system has been adopted, or is about to be adopted as a coal conservation measure in Detroit, Washington, Baltimore, Brooklyn, Cincinnati, Columbus, Dayton, Toledo, Indianapolis, Evanston (Ind.), South Bend, Newark (and the other cities of New Jersey), New Haven (and all the other cities of Connecticut), and in Oakland, Berkley and Alameda, California.

The Connecticut Company has reported a saving in fuel of 10 per cent. for its New Haven lines and reports indicate saving in the other places at rates varying from 3600 tons per year in Columbus to 21,000 tons per year in Detroit.

Various schemes for reducing car heating have been contemplated, but as yet no definite plans have been formulated.

3. ECONOMY IN UTILIZATION OF POWER AND LIGHT IN FACTORIES

The United States Fuel Administration is requesting, as a means of accomplishing power and light conservation in manufacturing and industrial establishments, the appointment, by the management, of a Shop Committee, composed of those best suited for the purpose and in size or number suitable to the size of the plant, one member of this committee to act as its chairman. The committee to be active with, and have charge of all details in the operation of the plant, that would in any way contribute to economy in fuel or that which fuel is used to produce and report weekly to the management or head of the plant.

It is also suggested that this committee be changed from time to time, so that the spirit and interest in this work may be maintained.

It is not the purpose arbitrarily to outline in detail the method for doing this work, rather to suggest in a general way, leaving the details and adoption of the plan in the hands of the manufacturers interested, as we realize that conditions in different plants and character of manufacture, as well as organization, will have a bearing on the size, character, and details of the committee, which must be suited to the particular case under consideration.

As a typical illustration of possible waste and opportunity for conservation, we suggest the following items:

1. Lights being unnecessarily burned.
2. Lamps of too high candle power.
3. The elimination of carbon lamps in favor of Mazda lamps where practicable.
4. The elimination of arc lamps and substitution of nitrogen filled lamps which are from two to three times as efficient.
5. The restricted use of sunlight due to dirty windows.
6. Operation of motors when machinery is idle.
7. Excessive sparking, heating or erratic speed of motors.
8. Improper alignment of shafting.
9. Grouping of machines so as to operate motors or engines as nearly loaded as possible.
10. Staggering of operations so as to maintain as flat a load curve as possible.
11. Slipping belts.
12. Dry bearings.
13. Overheated or underheated parts of plant.
14. Excessive drafts due to lack of proper protection about openings of doors, windows, elevator and staircase areas.
15. The reduction of elevator service or the application of a Skip-stop to elevator service.
16. The testing out of power circuits for relationship of capacity to load carried.
17. The paralleling of power circuits.

We also suggest that the work of this committee be conducted in such a manner as to provide records of

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savings, which could be incorporated in reports and information desired from time to time as to the progress of this work.

The War Industries Board and the United States Fuel Administration are laying particular stress upon the assistance that can be rendered by Industries in economizing in the use of fuel and power.

For the purpose of recognition of the individual service and interest of the members of committees, the Government will designate and identify them with a button or badge which will be furnished by the United States Fuel Administration.

The endeavor to bring about conservation by the above means is well under way in several sections of the country. Reports which have come in show savings in fuel ranging from 10 to 34 per cent.

4. UTILIZATION OF EXCESS WATER POWER AND INTERCONNECTION OF POWER SYSTEMS

A method of fuel conservation which promises a certain amount of immediate relief and at the same time opens up a field with almost limitless possibilities for future development is the interconnection of the present power systems of the country, and the consequent utilization of considerable excess water power which is at present available.

In many parts of the country duplicate transmission systems exist, serving practically the same territory. An interconnection between these systems for the mutual exchange of energy, would, in many cases, result in marked economies. In other cases, the lines of a power company which derives all, or nearly all, its energy from water power, may extend very close to the lines of another company which uses coal, to a large extent for the generating of power. Since no company is so fortunate as to be operating with a 100 per cent. load factor, there are necessarily times during light load, when the water-power company is forced to allow unproductive water to flow over its dam. At such a time a great saving in fuel would be effected were the two companies tied together and the load on the steam station transferred in part, or entirely to the water-power plant. Numerous hydroelectric companies have for a long time been carrying out this idea within their own systems, where the bulk of their power is derived from water and at the same time they maintain a steam reserve to carry their load during low water periods.

In some cases these system-interconnections would involve a considerable expenditure of both time and money, in which event they would not be subject to immediate aggressive action by the Administration but would be held in abeyance as possibilities for future consideration and developments. In a great many instances, however, very considerable savings can be effected with a minimum of delay and expense, and it is along these lines that the first efforts will be most energetically directed.

5. LIMITING THE PRODUCTION OF POWER TO THE MOST EFFICIENT PLANTS AVAILABLE

We have been able to locate nearly 500 instances thruout the country where there exists, in one form or another, a duplication of power production and supply. In other words, there are communities where two or more central stations are furnishing electrical energy with systems paralleling one another.

In certain instances the results of such a condition are not serious and in many cases probably unavoidable. Our investigations so far, however, have proved that a very large percentage of these situations offer an opportunity for large fuel conservation.

We find very often that an arrangement can be made at little or no expense whereby paralleling systems might be connected and the entire load supplied from the more economical station. In some cases, possibly, the combined load of both systems would be greater than could be handled by the more economical station. In such case, as much load as possible should be carried by the station having the highest efficiency and the remainder taken by the other.

6. ECONOMY IN THE REFRIGERATING-AND-ICE-MANUFACTURING INDUSTRY

In coöperation with the Joint Commission on Refrigeration, which was organized to assist the Government during the war, the Power and Light Division is planning to get in touch with the entire ice industry to introduce a number of proved economies in the operation of ice and refrigerating plants.

A number of suggestions have already been made by the Commission and by individuals connected with the industry. One plan that possesses merit and has possibilities of considerable fuel saving is that of allotting a definite amount of coal to individual plants, depending upon the size and type of plant, such allowances being based upon a reduction of 10 to 15 per cent. of the average present fuel consumption. This will make it necessary to adopt many simple measures of economy that are now being overlooked.

Another possibility is that of producing white or opaque ice at a fuel saving of 5 to 20 per cent. This is accomplished by eliminating the power that is usually

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used for agitation in raw water plants and for producing distillate in distilled water plants, both of which are merely means of producing a transparent product. This measure is possible of adoption in many territories.

A further line of effort which will be productive of considerable economy and one that was successfully applied last winter is that of operating during the winter season only the most efficient plant, or plants, as the particular case requires, in communities where, during the summer season, all plants are required. This can be done and the individual business of each manufacturer will not be interfered with as the arrangement provides that the operating plant or plants will sell at wholesale rates to those manufacturers whose plants are temporarily closed down.

This arrangement also produces a saving in ammonia, and for this reason was applied last winter at the request of the Food Administration.

In general, as regards the program outlined above, other important measures of conservation will be affected.

First.—By the closing of plants or the consolidation of plants there will be rendered available skilled men who are vitally needed in the many war industries of this country. Provisions are now completed whereby men with such training will be assisted in obtaining profitable work suitable to their ability.

Second.—In many parts of the country there exists at the present time a power shortage. The interconnection of systems, the diversity factor of these systems considered, will render available additional quantities of power. The Council of National Defense is examining all communities where there is a surplus of power, having in mind the possible establishment in such communities of industries.

It may be stated that the conservation efforts of the Fuel Administration along the above lines are being directed so as to best serve the interests of all with a minimum of inconvenience and cost and with the object of making the coal supply that is available go as far as possible, so as to prevent the necessity of further drastic measures such as were necessary in January.

It will be patent to every reader that in the face of a great potential shortage it would be criminal for the Fuel Administration to neglect obvious means of fuel saving such as outlined above and equally criminal for the individual plant owner to refuse or defer coöperation which may have as a direct result a loss in production of war materials or which may jeopardize the health of many families thru shortage in coal supply. The Administration believes it should not be necessary to resort to the issuing of orders for the adoption of these conservation measures but is relying, as in the past, upon voluntary action by those concerned and does not wish to enforce the measures where the saving in fuel would result in hardship to the owners not commensurate with the benefit derived by the public.

In this spirit, the Fuel Administration invites coöperation, whether the question be one of interconnection, of operation of plants at maximum efficiency, or of temporary closing down of plants. We invite suggestions and criticism of a constructive nature from all sources.

WILL YOU VOLUNTEER?

The United States Fuel Administration has placed an urgent call for volunteer help in connection with the inspection of boiler plants and power houses thruout the State.

The work consists of making a cursory inspection of such power plants or manufacturing boiler plants, upon advisement, in locations convenient to your residence or business office. These inspections would not take over an hour at the plants, and are simply to be answered "yes" or "no" in checking up the reports of the manufacturer or owner in such questions as: Are the steam pipes properly jacketed; is the feed water heater used; and other matters of similar tenor.

Members of the Engineers' Club of Philadelphia:
Are you willing to do this from a patriotic standpoint?

As this matter is of great importance in view of the contemplated fuel shortage next winter, kindly advise the Secretary's office, Engineers' Club, immediately, and you will be enrolled as volunteer inspectors and provided with proper cards of certification which will be issued from Washington.

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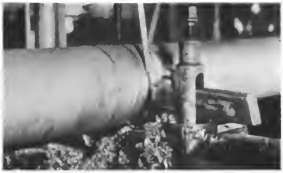

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EDGAR MARBURG

1864—1918

AT the meeting of the Board of Directors of the Engineers' Club of Philadelphia, held July 9th, 1918, the following preamble and resolution was unanimously adopted:—

> "The Engineers' Club of Philadelphia learns with profound sorrow of the death, on June 27, 1918, of its beloved fellow-member and Past President, Edgar Marburg. The Engineers' Club has, in the death of Edgar Marburg, lost one of its most valued members, whose loyal service has left a deep impression on the history and development of the Club, whose scholarship has earned him an international reputation and whose personal influence has helped the members in their work and professional advancement.
>
> The Engineers' Club extends to his family its warmest sympathy in their bereavement and sorrow; and, as an acknowledgment of his loyalty, brilliant leadership, kindly sympathy, ready helpfulness and professional ability, it is directed that this resolution of condolence and regret be published in the Journal of the Engineers' Club, together with a sketch of his life."

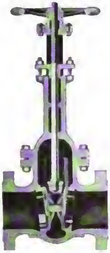
Edgar Marburg, a member of the Engineers' Club of Philadelphia since October 21, 1893, was born in Shreveport, Louisiana, March 4, 1864. He was graduated from Rensselaer Polytechnic Institute, Troy, New York, in 1885, with the degree of C.E. Later, upon the completion of the present Engineering Building of the University of Pennsylvania, he was honored with the degree of Sc.D. Four years ago, the degree of LL.D. was conferred on him by Franklin and Marshall College.

In 1895 and 1896 Professor Marburg was elected one of the Directors of the Engineer's Club, and in 1900 was elected President. He was Chairman of the Committee on Public Relations in 1912, a committee first appointed during that year; and from March 21, 1908, until his death was one of the Trustees of the Bond Redemption Fund.

Professor Edgar Marburg held the chair of Civil Engineering in the University of Pennsylvania for twenty-six years, and, in conjunction with the late Professor Henry W. Spangler, deserves credit for having planned the present engineering laboratories at the University.

He was Secretary of the American Society of Testing Materials, a member of the American Society of Civil Engineers, and the Society for Promoting Engineering Education. He contributed to various engineering journals, and was connected editorially with the *Engineering News-Record*. His most complete and important work was entitled "Framed Structures and Girders."

Professor Marburg is survived by his widow, who was Miss Fannie Moncure, of Shreveport, Louisiana, his father and mother and four children, his only son being at present in the United States Army.



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TWO valves may seem very much alike, but in service their performance may be as different as night and day. This difference may be due to the metal, the design, or the workmanship. But wherever it is, it usually can be found. Take a cross section, like that of the **NELSON** valve shown above, and examine it thoroughly.

Heavy Steel Castings throughout. Full, clear opening of port when discs are raised.

The double disc gate consists of two separate discs on a central wedge, closing against tapered seats. Accurately machined guides in the body hold the discs in line during travel, take the strain and prevent chattering and scraping of seats. Discs move freely in these guides to their lowest point and are then wedged tightly against the seats, rocking on the wedge into any position required for perfect seating. Great flexibility is thus secured in the seating mechanism.

Seat rings, disc faces, stem and bonnet bushing are monel.

Hand wheel has cork grips.

Valve can be packed when open.

Bonnet is exceptionally high, providing a deep stuffing box and long condensing chamber. This contributes to long life of packing.

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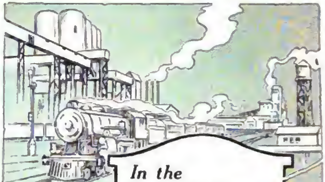

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Long life, infrequent repairs, absence of seats and discs, protected packing which lasts from two to seven years, ease and certainty of operation—are some of the features of this dependable blow-off valve.

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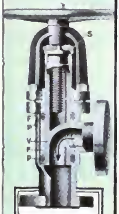

Operation

In closing valve, shoulder "S" on plunger "V" engages the loose follower gland "F," compressing packing "P" above and below the part, making an absolutely tight valve.

YARWAY Seatless Blow Off Valve formerly the SIMPLEX

COMMITTEE ON MEMBERSHIP

PAUL SPENCER, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before August 12 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

THOMAS WILLIAM CLARKE

Emergency Fleet Corporation, 140 N. Broad St., Philadelphia.
Traveling Engineer, U. S. Shipping Board, Emergency Fleet Corporation.
Proposed by E. F. Cobb and Edwin Smith.

JOHN J. A. DEVINE

1719 Arlington St., Philadelphia.
Field Engineer with Keystone State Construction Co., Broad and Filbert Sts., Philadelphia.
Proposed by Wm. Pool Parker and S. M. Swaab.

JAMES PAGE HARBESON, JR.

1206 Eldridge Ave., West Collingswood, N. J.
Plant Engineer, Camden Forge Company, Camden, N. J.
Proposed by R. G. Coolbaugh and A. C. Wood.

WITOLD LESNIEWSKI

Emergency Fleet Corporation, 140 N. Broad St., Philadelphia.
Assistant Power Specialist, Emergency Fleet Corporation.
Proposed by Walter N. Polakov and J. F. Stevens.

RALPH H. LOVELL

140 N. Broad St., Philadelphia.
Chief Engineer, U. S. Shipping Board, Emergency Fleet Corporation.
Proposed by W. P. Taylor and B. A. Haldeman.

ROBERT JOSEPH LYONS

Emergency Fleet Corporation, 140 N. Broad St., Philadelphia.
Assistant Purchasing Officer, Emergency Fleet Corporation.
Proposed by A. L. Robinson and J. J. Staley.

LINN O. MORROW

19th and Hamilton Sts., Philadelphia.
Sales Engineer, Cutter Elec. and Mfg. Company.
Proposed by H. P. Liversidge and H. C. Albrecht.

CHARLES W. PARKHURST

1120 Commercial Trust Bldg., Philadelphia.
Engineer, Berwind-White Coal Mining Co.
Proposed by H. F. Sanville and J. F. Stevens.

EDWARD P. ROBERTS

79 Atlas St., Akron, Ohio.
Efficiency Engineer, The Philadelphia Rubber Works, Akron, Ohio.
Proposed by Houston Dunn and W. L. Plack.

DAVID T. WILLIAMS

The Kennington, 1330 Pine St., Philadelphia.
Mechanical Engineer, Emergency Fleet Corporation, Philadelphia.
Proposed by W. P. Taylor, B. A. Haldeman and Philip S. Tyre.

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It is desirable to have these men act as volunteers where possible, but the administration is prepared to pay a reasonable compensation for men who cannot afford to give their services to the government.

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Washington, D. C.

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Apply 220-A, Engineers' Club.

Wanted.—Young men, technical graduates, to teach in Ground School for Aviators. Teaching experience not required. Special arrangements for men in the draft.

Apply 221-A, Engineers' Club.

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SECRETARY'S NOTICES

ABSTRACT OF MINUTES OF ORGANIZATION MEETING OF THE BOARD OF DIRECTORS THE ENGINEERS' CLUB OF PHILADELPHIA

JUNE 19, 1918

The meeting was called to order at 7.15 P.M. with President Stevens, Vice Presidents Eglin and Wagner, Directors Connell, Gant, Long, Spencer, Swaab, Lee, Douglas, Past President Carter, Treasurer Kenney and Secretary Stockly in attendance. Vice President Andrews, Directors Hayward, Lauer, Murphy, Quimby, Terrell, Ehle, Barr, Past Presidents Ledoux and Vogleson were excused.

The President announced the appointment of the following Committees for the year beginning July 1, 1918:

Executive:

J. Franklin Stevens, Chairman.
Wm. C. L. Eglin,
Jos. C. Wagner,
H. P. Gant,
Walter E. Long.

Finance:

Walter E. Long, Chairman.
Paul Spencer,
Guilliaem Aertsen,
Lewis H. Kenney,
George R. Henderson.

House:

Wm. Pool Parker, Chairman.
H. P. Gant,
M. M. Price,
E. F. Cobb,
H. F. Sanville,
Chas. F. Iszard,
H. B. Allen,
Chas. F. Puff, Jr.

Papers:

Lewis H. Kenney, Chairman,
David E. Smiley,
Wm. Pool Parker,
S. M. Swaab,
H. F. Sanville,
H. P. Gant,
J. A. Steinmetz,
G. M. Spear,
C. R. Spare,
M. W. Franklin.

Publication:

David E. Smiley, Chairman.
Samuel T. Wagner,
John P. Mudd,
Lewis H. Kenney,
George A. Hoadley.

Meetings:

S. M. Swaab, Chairman.
Lewis H. Kenney,
J. A. Steinmetz (A.S.M.E.)
C. B. Voynow (A.S.C.E.)
W. P. Dallett (W.T.C.)
R. E. Page (M.I.T.)
A. P. Goldsmith (A.S.H.V.E.)
C. E. Clewell (I.E.S.)
C. C. Black (P.S.C.)
N. S. Pringle (S.A.E.)
——— (A.I.E.E.)

Membership:

Paul Spencer, Chairman.
A. W. Bartlett,
H. F. Sanville,
A. C. Wood,
Chas. F. Puff, Jr.

Public Relations:

George R. Henderson, Chairman.
Emmett B. Carter,
Robert H. Fernald,
S. L. Kneass (A.S.M.E.)
A. F. Damon, Jr. (A.S.C.E.)
George A. Denny (W.T.C.)
Thomas Sproule (I.E.S.)
C. J. Walton (M.I.T.)
H. W. Forster (P.S.C.)
W. H. Palmer, Jr. (S.A.E.)
M. W. Franklin (A.S.H.V.E.)
——— (A.I.E.E.)

Trustees of the Bond Redemption Fund:

Henry Leffmann, Chairman.
Edgar Marburg,
Edwin F. Smith.

Tellers:

George E. Crofoot, Chairman.
John P. Mudd,
George A. Dickel,
Chas. F. Puff, Jr.,
Stewart A. Jellett, Jr.

By-Laws:

Robert H. Fernald, Chairman,
Robert M. Barr,
John C. Trautwine, Jr.
Wm. H. Connell,
T. D. Just.

National Service:

Guilliaem Aertsen, Chairman.
Wm. C. L. Eglin,
F. K. Worley,
Walton Clark,
J. W. Ledoux.

Increase of Membership:

H. F. Sanville, Chairman.
(Additional members to be appointed)

Affiliated Societies:

Carl Hering, Chairman.
J. A. Branegan,
W. L. Plack,
Howard W. Dubois.

Building:

F. C. Dunlap, Chairman.
S. M. Swaab,
Wm. H. Connell,
Manton E. Hibbs,
Wm. Pool Parker.

Conservation of Fuel:

Walton Clark, Chairman.
George R. Henderson,
Robert H. Fernald,
Emmett B. Carter,
H. F. Sanville,
R. L. Moody,
A. C. Wood.

Life Membership:

W. P. Dallett, Chairman.
Carl Hering,
Wm. C. L. Eglin,
Wm. Pool Parker,
Wm. H. Walters.

It was recommended that the Executive Committee be empowered to elect members during the summer months.

Action: Recommendation approved.

Mr. H. A. Stockly was elected Secretary of the Club for the year beginning July 1, 1918.

The meeting adjourned at 10.10 P.M.

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ABSTRACT OF MINUTES OF SPECIAL MEETING OF BOARD OF DIRECTORS, THE ENGINEERS' CLUB OF PHILADELPHIA

JULY 9, 1918

The meeting was called to order at 7 P.M., with President Stevens, Vice President Wagner, Directors Long, Spencer, James, Quimby, Lee, Newkirk, Treasurer Kenney and Secretary Stockly in attendance. Mr. Guilliaem Aertsen, member of the Committee on Finance, was also present, on request. Vice Presidents Andrews and Eglin, Directors Connell, Gant, Swaab, Murphy, Douglas, Terrell, Barr, Past Presidents Ledoux, Carter and Vogleson were excused.

The minutes of the Regular Meeting of June 11, 1918, and the Organization Meeting of June 19, 1918, as issued to the members of the Board, were approved.

REPORT OF THE PRESIDENT

A suggested draft of resolution prepared by Doctor Hering and Mr. Kenney, to be sent by the Board to the family of Doctor Marburg, was adopted, to be edited by the President.

Doctor Carl Hering was appointed to fill the vacancy existing in the membership of the Trustees of the Bond Redemption Fund by reason of the death of Doctor Marburg.

REPORT OF THE SECRETARY

The following deaths are announced:

Rudolph R. Baizley (active), elected June 20, 1885, died June 4, 1918.

Edgar Marburg (active), elected October 21, 1893, died June 27, 1918.

James T. Maxwell (active), elected November 29, 1915, died May 27, 1918.

Harry W. Prince (junior), elected December 21, 1915, died June 11, 1918.

Resignations from the following members were presented and accepted:

C. H. Chubbuck
Henry A. Laughlin
Edward Lupton
W. S. Nichols
J. W. Walker
H. R. West

REPORT OF THE TREASURER

The Treasurer presented a report which was accepted.

REPORT OF THE COMMITTEE ON MEMBERSHIP

At the recommendation of the Committee the following were elected:

To *Active* Membership:

Robert H. Anderson
Leonard C. Butler
Francis W. Dean
J. Price Ewing
Jonathan C. Hinton
W. M. Marks
James H. Wood.

The meeting adjourned at 9.30 P.M.

H. A. STOCKLY,
Secretary.

COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, Chairman

"From these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion; these dead shall not have died in vain."—Abraham Lincoln.

Barker, Edward Williams, Sergeant	Junior Member	Died March 17, 1918, Camp Meade, Admiral, Md.
Prince, Harry Walter, 1st Lieutenant	Junior Member	Died June 11, 1918, England

MEMBERS OF ENGINEERS' CLUB WHO HAVE BEEN CALLED INTO SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES AS OF JULY 25, 1918

NAME	RANK	CORPS	LOCATION
Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, H. Butler	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, via New York
Allen, J. G.		Co. 12 Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Anders, D. W.	Major	Company D, 502nd Engineers	American Expeditionary Forces, France
Andrews, J. H. M.	Major	Ordnance R. C.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
Asplundth, E. T.	Captain	103rd Engineers	American Expeditionary Forces, via New York
Atterbury, W. W.	Brigadier-General	Director-General of Railways	France
Baker, W. D.	2nd Lieutenant	Aviation Corps	France
Banister, E. S.	Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Barnes, H. P.		Naval Flying Corps Mass. Inst. Technology	Cambridge, Mass.
Barnes, F. B.	Master Engineer	Headquarters Department 26th Engineers	American Expeditionary Forces, via New York
Bassett, F. H., Jr.		Officers' Training School	Camp Meade, Md.
Bauman, C. W.	Lieutenant	Co. "E" 103rd Engineers	American Expeditionary Forces, via New York
Bear, H. K.	Lieutenant	Gas Defense Service	Camp Greenleaf, Ft. Oglethorpe, Ga.
Beatty, L. B.	Ensign	U. S. Naval Reserve Force	705 Parker Ave., Collingdale, Pa.
Bell, Frank P.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
Bescherer, P.	2nd Lieutenant	319th Heavy Artillery	Camp Gordon, Ga.
Betus, A. J.	Major		A. P. O. 720, American Expeditionary Forces, via New York
Biester, W. H., Jr.	Corporal	"Co. E," 103rd Engineers	American Expeditionary Forces, via New York
Bishop, A. B.	2nd Lieutenant		Call Field, Wichita Falls, Texas
Booz, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	Amer. Exped. Forces, via New York
Borden, J. M.	2nd Lieutenant	Ordnance Reserve Corps	Hudson Motor Car Co., Detroit, Mich.
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. P.	Lieutenant Engineer Officer	U. S. Naval Reserve Force	Submarine Base, New London, Conn.
Boyd, G.	1st Sergeant	Gas Service	A. P. O. 717, American Expeditionary Forces, via New York
Bradford, J. S.	Major	103rd Engineers	American Expeditionary Forces, via New York
Bradt, Morris	1st Lieutenant	Ordnance Officers' Reserve Corps	Hqrs. Base Section No. 3, Line of Communication. A. E. F., Goring Hotel, Grosvenor Gardens, London, S. W. 1
Bransome, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
Bream, C. C.	Corporal	103rd Engineers	American Expeditionary Forces, via New York
Breen, J. W.	Captain	Gas Service, Engineer Officers' Reserve Corps	Amer. Exped. Forces, via New York
Brewer, P. C., Jr.	2nd Lieutenant	307th Engineers	American Expeditionary Forces, via New York
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Britten, D. L.	Captain	Ordnance Officers' Reserve Corps	Inspector of Ordnance, Haddon Apts., Cleveland, O.
Broadhead, Alex		19th Reserve Engineers	American Expeditionary Forces, via New York
Brogan, C. M.		Quartermaster's Corps, Utility Detachment, Barracks "B"	Camp Meade, Admiral, Md.
Brown, J. A.	Major	Ordnance Officers' Reserve Corps	Smithtown, L. I., New York
Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier-General W. W. Atterbury
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, via New York
Brown, R. V.	Lieutenant	Q. M. C., 304 Divisional Trains	Camp Meade, Admiral, Md.
Brown, W. F.	1st Lieutenant	520th Co., N. A.	Fort Myer, Va.
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.
Bryant, C. M.		Naval Coast Defense	Philadelphia Navy Yard
Butler, E. N.	1st Lieutenant	103rd Engineers	American Expeditionary Forces, via New York
Caccavajo, Jos.	Major	Engineer Officers' Reserve Corps	France
Cahill, E. H.	1st Lieutenant	Ordnance Reserve Corps	Washington, D. C.

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Campbell, C. C.		Motor Co. 13 Section "B"	Camp Greenleaf, Ga.
Carney, R. E.	Asst. Engr. U. S. N. (Retired)	Pearl Harbor Naval Station	Hawaii
Chance, T. M.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Childs, H. P.	1st Lieutenant	23rd Engineers	American Expeditionary Forces, France
Clark, J. W.		Russian Railway Service	Nagasaki, Japan
Cleeland, R.	Cadet Engineer	S. S. Neuse	Care U. S. Shipping Board
Colgan, R. J.	Captain	11th Regiment Engineers	Care of Adjutant-Gen'l, Washington, D. C.
Craig, Coulter	Captain	Ordnance Officers' Reserve Corps Supply Division	Office, Chief of Ordnance Washington, D. C.
Crampton, G. S.	Major	Director of Field Hospitals, 28th Div.	American Expeditionary Forces, via New York
Crowther, E. C.	1st Sergeant	Base Hospital No. 38	Second Regiment, N. G. P., Armory, Philadelphia
Cumings, C. A.	Captain	Quartermaster Officers' Reserve	Ft. Sam Houston, Texas
Custer, E. A.	Major	Ordnance Officers' Reserve Corps	Chamber of Commerce Bldg., Pittsburgh, Pa.
Cutler, James B.	2nd Lieutenant	319th F. A. R. C.	Camp Gordon, Ga.
Darlington, I. G.	1st Lieutenant	Gun Section, Production Division	Washington, D. C.
Davies, C. E.	Lieutenant	Ordnance Department, U. S. A.	Frankford Arsenal, Philadelphia
Day, R. F.	2nd Lieutenant	Aviation Corps	3rd Squadron, Ellington Flying Field, Houston, Texas
Dechant, F. H.	Ensign	U. S. Naval Reserve Force	Bureau of Yards and Docks, Quantico, Virginia
Derby, C. F.	Captain	Ordnance Officers' Reserve Corps	Camp Lee, Petersburg, Va.
Dill, C. M.	Lieutenant	Headquarters Co., 10th Ba., F. A. R. D.	Camp Jackson, S. C.
Donnelly, J. B.	1st Lieutenant	103rd Engineers	American Expeditionary Forces, via New York
Doyle, T. H.	2nd Lieutenant	U. S. Quartermaster's Corps	Overseas Service
Dunlap, V. R.	Lieutenant (Jr.)	Ass't Civil Engineer, U. S. N.	Naval Air Station, Pensacola, Fla.
Dunn, M. L.	Ensign	"U. S. S. Connecticut"	Care Postmaster, N. Y.
*Dyson, C. W.	Rear Admiral	Bureau of Steam Engineering, U. S. N.	Washington, D. C.
Eckhardt, J.	Corporal	10th Regiment, 3rd Training Battalion	Camp Meade, Md.
Eisenbrey, R. H.	Captain	Ordnance Reserve Corps	B-1-309 Ordnance Buildings, Washington, D. C.
Elcock, Chas.	Captain	103rd Engineers	American Expeditionary Forces, via New York
Farr, Roy S.	2nd Lieutenant	Engineers' Reserve Corps	A. P. O. 713, American Exp'y Forces, via New York
Farrell, J. E., Jr.	2nd Lieutenant	Co. 1 B. 4th Regiment Engineers,	Camp Lee, Va.
Faust, W. D.		103rd Engineers	American Expeditionary Forces, via New York
Fenton, Powell	1st Lieutenant	Aviation Corps	American Expeditionary Forces, via New York
Ferree, D. S.	2nd Lieutenant	Aviation Section, Signal Corps	Ellington Field, Houston, Texas
Filbert, C. B.	Captain	41st Engineers	American Expeditionary Forces, France
Fish, W. N.	1st Lieutenant	Ordnance Reserve Corps	Fort Sheridan, Ill.
Floyd, H. B.	Private	Co. "C" 5th Pioneer Infantry	Camp Wadsworth, Spartansburg, S. C.
Forster, A. O.	Captain	Army Supply Base	59th St. and 1st Ave., So. Brooklyn, N. Y.
Frank, A.	Corporal	1st Replacement Regiment Engineers—Co. "A"	Fort Foote, Maryland
Fulweiler, J. E.	Lieutenant	Naval Coast Defense	American Expeditionary Forces, via New York
Gailing, H. W., Jr.	Private	Marine Corps (Aviation)	Philadelphia Navy Yard
Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	P. O. 717, American Expeditionary Forces, France
Gant, H. P.	Captain	Ordnance Reserve Corps	University Club, Washington, D. C.
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gaum, Carl G.	1st Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gauthier, Jordan	2nd Lieutenant	4th Platoon, Co. "C," 56th Engineers	Zone of the Advance, American Expeditionary Forces, via New York
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Getz, Ralph F.	2nd Lieutenant	32nd Engineers	Camp Grant, Ill.
Gilbert, W. T.		21st Railway Engineers	American Expeditionary Forces, via New York
Gillam, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Goldsmith, H. F.		Naval Aviation Training School	Cambridge, Mass.
Goodwin, H., Jr.	Lieutenant	U. S. Naval Reserve Force	Bureau of Naval Officers' Operations, 1728 G St., N. W., Washington, D. C.
Gracey, A. L.	Private	Advance Ordnance Depot No. 4	American Expeditionary Forces, via New York
Graham, W. R.	1st Lieutenant	Aviation Section Signal Officers' Reserve	Aviation Mob. Camp, Camp Sevier, Greenville
Gravell, W. H.	Captain	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Gray, B. D.	Major	Signal Corps, U. S. A.	Adams Bldg., Washington, D. C.
Gribbel, W. G.	Captain	30th Engineers, Gas & Flame Division	American Expeditionary Forces, via New York
*Griffin, R. S.	Rear Admiral	Eng. in Chief, U. S. N. Bur. of Steam Engineering	Washington, D. C.
Grossman, P. R.	Private	G. H. Q. Amer. Expeditionary Forces	U. S. M. P. O. No. 706, France
Gwilliam, Mark R. M.	Captain	21st U. S. Infantry	San Diego, Calif.
Hall, W. A.	Lieutenant	U. S. Navy, In European Waters	Base 17, Care of Postmaster, N. Y. C.
Hamilton, H. A.	1st Lieutenant	Engineer Officers' Reserve Corps	
Harding, R. L.	1st Lieutenant	Co. "F," 32nd Engineers	Camp Grant, Rockford, Illinois
Harrower, R. A.		American Red Cross Ambulance Corps	France
Hart, R. P., 2nd	Lieutenant	44th Engineers	Ft. Benjamin Harrison, Ind.

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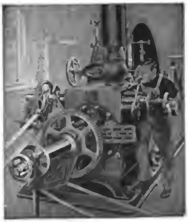

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Hathaway, H. K.	Lieut.-Colonel	Ordnance N. A.	Washington, D. C.
Havens, C. R.		Meteorological Squadron, U. S. Signal Corps	A. & M. College, College Station, Texas
Hayden, H. S.	2nd Lieutenant	103rd Engineers	American Expeditionary Forces, via New York
Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
Heger, J.	Lieutenant	Engineers' Depot	Washington, D. C.
Heinrich, K. W.	Lieutenant, N. N. V.	U. S. S. Iowa	Care of Postmaster, Fortress Monroe, Va.
Henderson, S. D.	Private	304th Engineers	Camp Meade, Admiral, Md.
Henry, J. C.	Sergeant	Headquarters Dep't 19th Reserve Engineers	A. P. O. 708 Amer. Exp. Forces, via New York
Hetherington, S. C.	Lieutenant	315th Infantry	Camp Meade, Admiral, Md.
Hickey, Y.	Second Lieutenant	Hqrs. 1st Bn., 61st Infantry	A. P. O. 728, American Exp'y Forces, via New York
Hollenbach, E. E.	Major	109th Infantry	Camp Hancock, Augusta, Ga.
Hollister, C. J.	1st Lieutenant	Dental Corps, 28th Division	American Expeditionary Forces, via New York
Houwen, W. P.	C. M. A. A.	United States Navy Air Station	Cape May, N. J.
Hulme, Norman	1st Lieutenant	458th Truck Co.	Fort Myer, Va.
Hunter, N. R.	2nd Lieutenant	47th Engineers	Camp Sheridan, Ala.
Hutchison, G. B.		Elec. School, Naval Operating Base	Hampton Road, Va.
Hyland, G. N.	2nd Lieutenant	Mather Field—Mills Station	Sacramento, Cal.
Jaques, J. D.	Lieutenant	U. S. N. R. F., Public Works Dept.	Navy Yard, Boston, Mass.
Jensen, J. A.	2nd Lieutenant	Chem. Service Section, N. A.	American University Exp. Station, Washington, D.C.
John, R. R.		Officers' Training School for Coast Artillery	Fortress Monroe, Va.
Jones, Jonathan	Captain	23rd Regiment Engineers	American Expeditionary Forces, via New York
Kennedy, J. H.	Cadet	8th Aviation Instruction Centre.	American Expeditionary Forces, via New York
Kent, S. L., Jr.	1st Lieutenant	34th Engineers	American Expeditionary Forces, via New York
Kern, F. X.	Lieutenant	23rd Regiment Engineers	American Expeditionary Forces, via New York
Klein, A. C.	1st Lieutenant	Production Section, Gun Division	Office, Chief of Ordnance, Washington, D. C.
Kneass, E.	Ensign	U. S. Submarine Base	New London, Conn.
Knight, C. C., Jr.	Lieutenant	318th Field Artillery, N. A.	Camp Jackson, S. C.
Koblle, W. F. B.	Sergeant	Signal Corps	Washington, D. C
Kraus, P. T.	Sergeant	Co. "D," First Telephone Battalion Signal Reserve Corps	Amer. Exp. Forces, via New York
Laverty, C. R.		Co. "F," 305th Engineers	Camp Lee, Va.
Lawrence, G. E.	Lieutenant J. G.	U. S. Naval Res. Force	U. S. S. "Nokomis," European Waters, care Postmaster, N. Y.
Lawson, T. W.	1st Lieutenant	109th Infantry	Camp Hancock, Augusta, Ga.
Lea, E. S.	Major	Artillery Ammunition Division	Frankford Arsenal
Lees, E. A.	1st Lieutenant	Company "E," 56th Infantry	Camp MacArthur, Waco, Texas
Levin, J.	2nd Lieutenant	Coast Artillery Reserve Corps	Fort Hancock, N. J.
Loeb, A. H.		154th Depot Brigade 1st Detachment	Camp Meade, Admiral, Md.
Lynch, N. H.		"F" Co., 6th U. S. Engineers	American Expeditionary Forces, France
MacGarrigle, G. L.	Private	Company "B," 103rd Engineers	American Expeditionary Forces, via New York
Maclean, M. R.	Major	Headquarters 5th Bn., 154th Depot Brigade	Camp Meade, Md.
Magee, J. W.	1st Lieutenant	446th Engineers' Pontoon Train	Washington Barracks, D. C.
Mahan, J. H.		U. S. Signal Corps Radio School	Columbia University, New York City
Mallon, G. J.	Lieutenant (Jr.)	U. S. Naval Reserve Force	U. S. S. "Mt. Vernon," care of Postmaster, N. Y.
Maltby, F. B.	Major	Engineer Officers' Reserve Corps	Army Building, New York
Mann, C. P.	1st Lieutenant	Coast Artillery Reserve Corps	Fort Revere, Mass.
Mardaga, L.	Ensign	U. S. Naval Reserve Force	Asst. Naval Inspector of Ordnance, Alloy Steel Forging Plant, Carnegie, Pa.
Martin, T. S., 3rd	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Mayburry, W. G., Jr.	Lieutenant	334th Field Artillery, National Army	Camp Pike, Ark
McCausland, J. R.	Master Engineer Senior Grade		U. S. Post Office 701, R. T. O., American Expeditionary Forces, France
McClintock, J. L.		U. S. Navy Radio Station	Atlantic City, N. J.
McCord, J. B.	Lieutenant-Colonel	Ordnance N. A.	American Expeditionary Forces, France
McCormick, J. C.	1st Lieutenant	Co. "C," 1st Engineers	American Expeditionary Forces, via New York
McCoy, J. F.	2nd Lieutenant	Aviation Section, Signal Corps	
McGarrigle, J. J.	1st Lieutenant	Anti-Aircraft, Artillery C. A. C.	American Expeditionary Forces, France
McMillan, H. L.	Major	Engineer Officers' Reserve Corps	Camp Humphrey, Va.
Millar, E. A., Jr.	1st Lieutenant	Ordnance N. A.	Camp Hancock, Augusta, Ga.
Mohr, C. F.	Private	Co. "B," 45th Engineers	Camp Humphrey, Va.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Moon, T. E.	Corporal	119th Ordnance Depot Co.	Camp Hancock, Augusta, Ga.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Murphy, H. C.	Ensign	U. S. Navy	Bureau of Ordnance, Navy Dep't, Washington, D. C.
Meyers, W. C.	Captain	Ordnance Officers' Reserve	Inspection Division Standard Steel Car Co. Butler, Pa.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	1st Lieutenant	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixdorf, F. S.		5th Company, Coast Artillery Officers' Training Camp	Fort Monroe, Va.
Nixon-Miller, M.	Captain	Captain Com'd'g Co. A. 19th Engrs. (Rwy)	American Expeditionary Forces, via New York

Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
***Oakes**, J. C.	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
Orr, M. W.	2nd Lieutenant	Field Artillery, Separate Detachment	American Expeditionary Forces, via New York
***Otwell**, **Curtis** W.	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Perry, **Edward**	Sergeant	Motor Truck Company No. 329	Camp Lee, Petersburg, Va.
Peterman, J. M.	2nd Lieutenant	5th Bn., 152nd Depot Brigade	Camp Upton, N. Y.
Peters, B. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pickles, W. W.	Chief Sanitary Inspector	American Red Cross Sanitary Unit No. 25	Extra Cantonment Zone Sanitation, City Hall, Augusta, Ga.
Pierce, D. T.		American Red Cross	France
Pike, **Clayton** W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Prichett, F. B.		103rd Trench Mortar Battery	American Expeditionary Forces, via New York
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	79th Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	Hqrs. 19th Reserve Engineers, Railway	Amer. Exp. Forces, via New York
Reed, **Thomas**	Captain	Ordnance Officers' Reserve Corp	Inspector of Ordnance. The Singer Mfg. Co. Elizabethport, N. J.
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Reninger, H. A.	Major	Headquarters, 103rd Ammunition Train, 28th Div.	Amer. Exp. Forces, via New York
Ridge, R. S.	Sergeant	Co. "A," 23rd Engineers	American Expeditionary Forces, via New York
Ridgway, J. J.	1st Lieutenant	Co. "F," 318th Infantry	Camp Lee, Petersburg, Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.	Private	201st Aero Squadron	American Expeditionary Forces, via New York
Rogers, J. I.	Lieutenant	United States Naval Reserve Force	U. S. S. Helenita, in care of Postmaster, Fortress Monroe, Va.
Roop, J. C.	Captain	17th Engineers	American Expeditionary Forces, via New York
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Russell, J. A.	Lieutenant	311th Engineers	Camp Grant, Rockford, Ill.
Ryan, E. J.	1st Lieutenant	T. C. N. A.	American Forces Woraret Camp, Wareham, England
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	Camp Hancock, Augusta, Ga.
Satterwhite, R. L., **Jr.**		Company 20, Naval Aviation Detachment	Massachusetts School of Technology Cambridge, Mass.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	New York Arsenal, Governor's Island, N. Y. Harbor
Schaum, O. W.	Aeronautical Mechanical Engineer	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
†**Schoch**, J. B.	Lieutenant	109th U. S. Infantry	American Expeditionary Forces, via New York
Schoff, A. L.	1st Lieutenant	Signal Corps, Land Division	Fort Worth, Texas
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defense Service, Med. Dept., U. S. A.	Washington, D. C.
Scull, M. A. H.	Lieutenant	Railroad Transportation Corps	U. S. A. P. O. 717, American Exp'y Forces, via New York
Shallcross, J. B.	Lieutenant	Ordnance Reserve Corps	Inspection Div., 6th & B Sts., N. W., Washington, D. C.
Shoemaker, **Frederick** F.		U. S. S. Suzanne, S P. 510	Cape May, N. J.
Sheahan, J. C.	2nd Lieutenant	M. T. S. A. P. O. 708,	American Expeditionary Forces, via New York
Shuster, W. H., **Jr.**	Lieutenant	314th Infantry	Camp Meade, Md.
Sigmund, **Paul** E.		1st Replacement and Training Regiment of Engineers	Washington Barracks, Washington, D.C.
Smith, A. H.	Sergeant	Utilities Detachment Quartermaster's Corps	Barracks B 104, Camp Meade, Admiral, Md.
***Smith**, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Ordnance Officers' Reserve Corps	The Remington Arms W. M. C. Co., Ilion, N.Y.
Spackman, H. S.	Major	Engineer Officers' Reserve	A. P. O. 702, American Exp'y Forces, via New York
Spillan, J. J. D.	2nd Lieutenant	103rd Trench Mortar Battery,	American Expeditionary Forces, via New York
St. John, **Everett**	1st Lieutenant	Coast Artillery Reserve Corps	Fort duPont, Delaware
Stevenson, W. L.	Lieutenant Commander	U. S. Naval Reserve Force	Care of American Consul, Bordeaux, France.
Stokes, D. B.	Major	Quartermaster's Corps, N. A.	Care of Hotel Burlington, Washington, D. C.
***Tawresey**, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	Major	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. P., **Jr.**	1st Lieutenant	Co. "A" 32nd Engineers,	American Expeditionary Forces, via New York
Thacher, C. H.	2nd Lieutenant	Co. "A" 510 Engineers' Service Battalion	American Expeditionary Forces, via New York
***Thomas**, R. S.	Colonel	22nd Engineers	Camp Sheridan, Montgomery, Ala.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Corporal	Ordnance Detachment "B"	Gunpowder Reservation, Edgewood, Md.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Maine"
Truhan, L. J. D.	Ensign	U. S. Submarine Base, Barracks "E"	New London, Conn.
Uhler, W. D.	Major	Quartermaster Corps, N. A.	Washington, D. C.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal

---

†Lieutenant James B. Schoch, of the 109th U. S. Infantry, has been cited for bravery by the French Staff for his magnificent work in re-forming his company after it had been cut off from the main body of troops, and his courage and coolness in fighting the way back to the new position.

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Voegelin, E.		10th Company	Barracks, Columbus, Ohio
Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Hqr's, 34th Artillery Brigade	Fort Adams, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces, via New York
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	R. R. & C., S. O. S.	American Expeditionary Forces, via New York
Webster, E. L.		Reconstruction Relief Work Friends' Unit of the Red Cross	France
Wentz, E. M.	Asst. Paymaster	U. S. Naval Reserve Force	U. S. S. Westmount, care of Postmaster, N. Y. C.
Wheeler, G. C.	Private	Base Hospital No. 18	American Expeditionary Forces, via New York
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	American Expeditionary Forces, via New York
White, J. A. Jr.	Private	20th Division 109th Infantry	American Expeditionary Forces, via New York
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Wilkinson, R. W.		Engineers' Training School	Carnegie Institute, New York
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps	Office of Inspector of Ordnance, U. S. A. Highland Park, Michigan
Wood, E. R. Jr.	Captain	18th Field Artillery, N. A.	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C.	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	Coast Artillery School	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Santa Fé, N. M.
Young, R. L.	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Aberdeen, Md.
Zeckwer, J. R.	Ensign	U. S. Naval Reserve Force	Ship Inspection Office, Philadelphia
*Zinn, George A.	Colonel	District Engineers' Office, Custom House	Portland, Oregon

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* Army and Navy member

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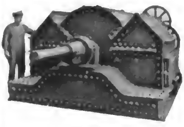
H. H. Quimby, President

C. W. Thorn, Secretary, 1313 S. Broad St.

THE following resolution was adopted at a special meeting of the Board of Direction of the Philadelphia Association of Members of the American Society of Civil Engineers, held July 8, 1918:

"*Resolved*, That the Board of Direction of the Philadelphia Association of Members of the American Society of Civil Engineers record, with the deepest regret, the loss which they and the engineering profession at large have sustained by the death of Edgar Marburg on June 27, 1918.

"As a member of the Board and a Vice-President since April, 1915, he was a most faithful worker and was always keenly alive to the best interests of the Society and the Association. His remarkable energy, enthusiasm and sincerity will always be remembered by those who were privileged to have been associated with him."



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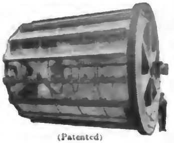

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THE JOURNAL OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

ORGANIZED DECEMBER 17, 1877
INCORPORATED JUNE 9, 1892

XXXV-9 SEPTEMBER, 1918 No. 166

ANNOUNCEMENTS

SPECIAL MEETING

At Bellevue-Stratford, Monday, September 16, 1918
8.00 P. M.

This will be a joint meeting with the American Institute of Electrical Engineers and the Association of Iron and Steel Electrical Engineers.

Mr. H. A. Hornor will present an illustrated address on Electric Welding—A New Industry. Mr. Charles M. Schwab will preside at the meeting.

The address will deal with the applications of electric welding to the shipbuilding industry.

Dinner will be served at six o'clock in the Stratford Room. Meeting will be held in the Clover Room.

REGULAR CLUB MEETINGS

The Committee on Papers has arranged for regular Club meetings during the present fiscal year to be held as follows:

October 15, Witherspoon Hall
November 19, Witherspoon Hall
December 17, Engineers' Club
January 21, Witherspoon Hall
February 18, Witherspoon Hall
March 18, Witherspoon Hall

The schedule of papers of the Club and of the affiliated societies will be prepared with a view to close co-operation and the development of our affiliation idea.

SPECIAL MEETINGS

Special Club meetings will be arranged during the year as opportunity offers. The Committee desires that members volunteer to present papers on research and other subjects which are of special technical value.

TUESDAY NOON LUNCHEONS

The Committee is co-operating with the Committee on House by arranging for speakers for our Tuesday noon luncheons. The addresses are informal and it is the desire of the Committees that the subjects presented be of general interest to the membership who attend these luncheons. Suggestions by the membership as to speakers and subjects for their addresses are invited.

JUNIOR PRIZE

The Junior Prize provided during the past two years by the Board of Directors is again to be competed for. The rules governing the award of prize were published in the August, 1917, Journal of the Engineers' Club. The Committee desires that the Juniors take an active interest in this subject because the prize was offered with a view to stimulating the preparation of technical papers by Junior members.

LEWIS H. KENNEY,
Chairman, Committee on Papers.

PUBLISHED MONTHLY BY THE ENGINEERS' CLUB OF PHILADELPHIA
UNDER THE SUPERVISION OF THE COMMITTEE ON PUBLICATION

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SUBSCRIPTION: Members, 25c. a copy, $2.00 a year. Non-Members, 35c. a copy, $3.00 a year. Foreign, 50c. a copy, $4.00 a year.

NOTE: The Club as a body is not responsible for the statements and opinions advanced in its publications.

Entered as matter of the Second Class, at the Post Office, Philadelphia, Pa., under the Act of Congress, March 3, 1879.

Acceptance for mailing at the special rate of postage provided for in section 1103, Act of October 3, 1917, authorized July 29, 1918.

Pag. o. 16.

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-9 SEPTEMBER, 1918 NO. 166

WAR STATUS OF GASOLINE AND FUEL OIL*

By JOHN D. GILL, Member

Not before the opening of the present world conflict has petroleum or its products been called upon to play a very important part in war. Iron, food, clothing, solid fuels, in times past, have been indispensable; today, however, petroleum products are just as necessary. If Germany's supplies of petroleum, and especially of gasoline or its satisfactory substitute, could be taken from her, her artillery would be blinded, her submarines made impotent; her wounded would often lie afield helpless; her soldiers compelled to fight at times hungry and at times without munitions, and her defeat materially hastened. Because these products are so essential to our enemy, they become even more essential to us who must overcome the handicap of deferred preparation and greater distance from the principal scenes of activity, since besides all that they can be to Germany, for us petroleum products must also be the savers of cargo space, the speeders of ships, protectors of our transports, and a right arm to our railroads.

THE past year has been a time peculiarly suited to engineers to give their thoughts to the bigger problems of the day—to the correlation of economic facts and technical conditions; to face, not so much questions of what is the best way of doing things, but what is the thing to be done. And then with the available resources of men and materials to go and do it; to compare needs with resources and see to it that war demands are first supplied. Therefore on this line of reasoning I may be permitted to hit the high spots of the present subject; to gloss over, with a few old matters in some new relations, a deficiency of new and experimental facts which for obvious reason cannot now be presented; to advance a theory or two on the solution of other problems and to make suggestion of some economic possibilities.

WHAT ARE GASOLINE AND FUEL OIL?

At this time I want to answer very briefly the question, "What is gasoline and what is fuel oil?" Gasoline is essentially a complex mixture of the lighter and more volatile hydrocarbon compounds found in most crude petroleums—a substance which readily mixes with air to form an explosive mixture—and obtained in the first distillation. It has no definite specific gravity nor a definite boiling point; its use very largely determines its general character and its specific properties.

Chemically, gasoline is a mixture of numerous normal and iso compounds for the most part of the so-called paraffin series, ranging from the gaseous butane, C_4H_{10}, to the comparatively viscous dodecane, $C_{12}H_{26}$, and contains about 84 per cent. carbon and 16 per cent. hydrogen. (For special purposes the range of compounds is much smaller, as, for example, between C_8H_{12} and C_9H_{20}.) These compounds are colorless and emit a faint etheral odor which by the oil man is called "sweet" to distinguish it from the odor of the pungent, unsaturated and sulphur-bearing derivatives of petroleum.

Commercially, and perhaps, for our present purpose, a better definition, gasoline is a mixture of these light petroleum distillates to which have been blended in various proportions the very light and extremely volatile hydrocarbons pressed (or absorbed) out of "wet" casinghead or natural gas; and the treated light distillates which result from the destructive distillation of heavy hydrocarbons by the process known commonly as "cracking." What the final value of the mixture shall be is determined by the quality of these three constituents, and the proportions in which they are used.

The fundamentals of good motor gasoline are that it shall contain enough very light constituents to permit easy starting of the engine and little or no heavy hydrocarbons to unduly retard combustion or give rise to incomplete combustion; and it shall contain nothing that will not burn in the engine cylinder under operating conditions. Such material will contain constituents which if isolated would boil violently when placed in the palm of the hand—compounds of which, because of their chemical nature, a very small portion is needed to form an explosive mixture. Herein resides the advantage of this fuel for motors over its incipiently more sluggish tho more uniform competitors.

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* Presented at the Annual Meeting of The Engineers' Club of Philadelphia, May 21, 1918.

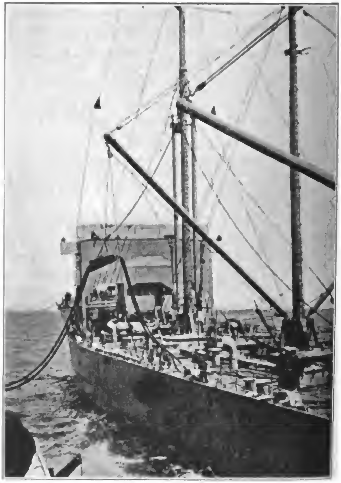
Physico-chemically, gasoline might roughly be compared to a thoroly mixed assortment of small coke particles ranging from dust to marble-size pieces—the dust representing the light volatile compounds and the larger pieces the heavier and high-boiling portions. By using sieves of different mesh the coke particles could readily be separated into "size" groups; by distillation, the constituents of the gasoline are similarly separated into "boiling-point" groups. The coke particles of all sizes are chemically alike; so the great bulk of the gasoline hydrocarbons belong to the same family. To continue the analogy (analogies are never complete), alcohol or rectified benzole might be represented by particles of, say, wood chips and lumps of bituminous coal respectively, the chips a little smaller than the lumps, but all the chips equal in size, and similarly the coal lumps—equivalent to saying that these compounds would have no boiling range, *i.e.*, would boil at practically a constant temperature.

Fuel oil, roughly speaking, is a mixture of liquid hydrocarbons, obtained from crude petroleum, for which no better purpose than burning under a boiler, in a furnace, or in a slow-speed internal combustion engine has been found. Like gasoline, it contains a great number of constituents of different boiling points—however, belonging to several hydrocarbon families—usually contains a small percentage of sulphur, up to 3½ per cent., and may contain a little non-combustible matter called by the oilman B. S. Fuel oil may be simply crude oil direct from the well except that water and dirt have been settled out of it —as in the case of some Californian and Mexican oils; it may be crude from which the light portions—gasoline and naphtha distillates—have been distilled ("topped") off; or it may be a distillate separated from the light end of the lubricating fraction of crude oil which has undergone several distillations and is usually a fairly uniform material of short boiling range. Fuel oil may have a jet-black or light amber color; it may be so viscous as to require preheating to a fairly high temperature before passing to the burner orifice, or it may be mobile enough to pass with ease thru a "cracked" needle valve. It may be nearly as heavy as water or almost as light as kerosene. A few decades ago fuel oil was "fuel oil"; today it is bought on rough specifications, but sufficiently complete to define the material. Fuel oil is preëminently the war fuel whether for shipping, as a cargo saver; for the fine regulation of heat treatment furnaces, or as labor saver in power generating plants. Let me quote a brief statement from the annual report of Secretary Daniels:

"The present war has demonstrated that our navy, to be of the maximum efficiency, must be composed of oil-burning units. The splendid work which has been accomplished by our destroyers could not have been carried out with coal-burning vessels. Neither could other tactical units of the fleet be constructed with their necessary military characteristics except by the employment of oil-burning boilers or internal-combustion engines."

Fuel oil will not evaporate at ordinary storage or bunker-room temperatures, does not deteriorate with standing, is not subject to spontaneous combustion, and is readily transferable. It requires considerable less storage space than solid fuels, gives an increase in boiler efficiency of 7 to 15 per cent., is quick of action, free from ash, regulated with ease, and can be obtained with reasonable uniformity.

But these advantages, which are so momentous in our every-day engineering practice of striving after mechanical perfection, take second place in war programs. It is speed that counts, whether one is chasing submarines or fleeing them. And fuel oil makes for speed—makes for the better protection of our boys "going over." Assistant Secretary Roosevelt has said: "The most perfect guns are rendered practically useless on a coal-fired ship if the opposing fleet with guns of the same caliber uses fuel oil. That oil fuel for the navy meant increased speed and cruising radius; control of smoke screens; reduced fireroom forces by 55 per cent; increased the efficiency of re-fuelling at sea by 25 per cent.; meant ability to sustain maximum speed for long periods of time without clogging furnaces; flexibility in speed; and finally, greater safety from submarines, as in modern American



FUELLING AN OIL-BURNING WARSHIP IN MID-OCEAN.

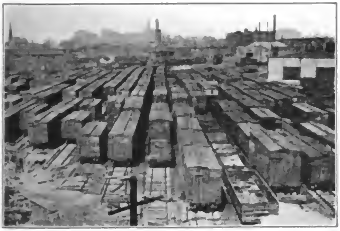
ships the fuel oil is disposed along the bottom to cushion the blow of exploding torpedoes."

And we need cargo space. Ships will win the war, we hear. Coal takes 43 cubic feet to the ton; oil, 36 cubic feet on the basis of their B.T.U. values, a saving of 45 per cent. of bunker space, and if you please to use the double-bottomed ballast tanks you save it all. The increased speed and saving in fuelling times means for us at least 10 per cent. additional tonnage.

WAR USES OF GASOLINE AND FUEL OIL

Now how else, besides on our ships, are these petroleum products being used to win the war? Early in the war Colonel Swinton saw the need for some device to cut down enemy entanglements and other defences. The petroleum-fed Land Cruiser—familiarly, the "tank"—capable of climbing walls, crossing trenches, pushing over trees, and manipulating very rough ground, was the result —to the enemy havoc, and to Allied soldiers confidence immeasurable. Perhaps of all its great functions that of being a big brother to the infantry has been one of its greatest utilities.

Another great use for fuel oil today is in the speeding of our railroads—our transportation. The freight congestion of last winter, which resulted in much suffering, particularly along the Eastern seaboard and especially in the large cities, New York, Boston, Philadelphia; the shutting of our factories, the putting into idleness of thousands of our workers; the stopping of many industries, which, while not absolutely essential to the progress of the war, are nevertheless desirable, could have been avoided or its consequences mitigated (and recurrence will be made difficult) by the proper mobilization and utilization of petroleum-fed vehicles. The elimination of forest-fire starting sparks, the saving of labor in numerous steam-generating plants—we have 225,000 such plants in the country—and the fine regulation of important temperatures in the heat treating of tool steels, armor plate and ordnance, and the reduction of labor in some departments of our power plants and munition factories to beyond 55 per cent. in some instances—important where man-power is at a premium—these are daily contributions of petroleum fuel to our war preparation.



FREIGHT YARD CONGESTION.

Guns are pulled by tractors where horses dare not tread; trenches are dug, wounded are carried comfortably and quickly to places of rest; submarines are chased by destroyers at marvellous speed; supplies are carried in abundance to the place of need, and the powerfully engined airplane (200–300 H.P., using more gasoline per hour than the average motorist will use per day) directs our artillery, flies like the screaming eagle over our advancing infantry, watches the enemy movements behind his lines, and now at last gives him a taste of his bombing.

The motor truck saved Paris at Verdun; and it is altogether likely that the motor truck, not more than five weeks ago, bringing up the French reinforcements, saved the British army in the recent terrific onslaught of the Germans, directed toward the cutting off of the British, when they were well-nigh exhausted.

Perhaps one of the most important but less spectacular utilizations of petroleum toward the winning of the war lies just here in the heavy motor truck. It has done splendid work abroad—it is doing splendid work at home.

Railroads need termini and termini spell congestion. The motor truck divides the responsibility. It is mobile; it goes nearly where it pleases.

THE MOTOR TRUCK AND THE RAILROAD

Prompt dispatch is today the watchword of all war industries. A day may mean 10,000 men lost at the front. Efficiency of the methods of the conduct of business must largely be gauged—not on cost—on the time saved by the method.

Could our soldiers on the other side wait for railroads to ship to seaboard points supply trucks which were sorely needed? Train after train of trucks left points west—Cleveland, Buffalo, Detroit—and steadily, regularly proceeded across the great national highways to their destination, loaded with supplies. Was it a costly process? More costly in point of direct expense than shipments by freight would have been on such long runs. Yet we are too prone to think the truck an expensive medium of transportation. Our roads are not to be compared to steel rails for low depreciation on equipment, yet when the army wanted to send a body of 500 men and officers from Douglas, Arizona, to the Roosevelt Dam, a distance near 665 miles, it sent them by motor at a cost of about $650—less than .2 cent per mile. Railroad fares would have been over $11,000, something more than 3 cents per mile per man. Motor-truck transportation, however, has its greatest usefulness at present in the short hauls of urban and some interurban delivery. It permits the railroads to function properly on the long hauls, and to haul constantly. And in such work economy of time by motor truck is backed by very reasonable costs. For certain short hauls on railroads in this part of the country it costs from 20 cents to 60 cents per ton-mile. The same hauls are made by 5-ton motor trucks for 18 cents to 40 cents per ton-mile, including all costs; and delivers the goods to the consumer's door, whereas railroad freight must often be handled a second time from the station to the consignee by dray.

There are in this country at present about 450,000 motor trucks (not including thousands of small delivery motor trucks), many of large capacity; the average probably being nearly of 3 tons. The average yearly mileage of such vehicles is about 15,000 miles, altho on straight medium-distance hauling 20,000 miles would be an easy accomplishment. This army of vehicles is capable of working at the rate of 10,000,000,000 ton-miles per annum, a real auxiliary to the railroads.

I want here to digress for a moment to mention a matter that may not be common information.

The magnitude of the rated and actually generated horsepower of the motor vehicles of the country has perhaps been overlooked because we think only of small units, not ordinarily exceeding 50 H.P. A comparison, therefore, of the total available horsepower of the motor vehicles of a given locality and the total rated horsepower of the stationary units of the same section—of even an industrial and consequently large power-generating city like Philadelphia—is at first blush startling. For example, there will be in Philadelphia in 1918 a total of approximately 800,000 primary stationary H.P. This figure is based on the governmental industrial census of 1914, which gave 647,400 H.P. to the Philadelphia metropolitan district, of which Philadelphia city has in the neighborhood of 80 per cent. This showed an increase of 30 per cent. during the 5-year period between the 1909 and 1914 census. Assuming a 50 per cent increase for the four years following 1914 gives us a total for 1918 of 778,000, or approximately 800,000 H.P. for Philadelphia city.

There are, or will be, in Philadelphia this year—allowing for one-half the increase rate of the last several years—65,000 to 68,000 motor cars whose average horsepower at maximum load may be taken at 30.

The total horsepower available thru working at the maximum would be over two million—more than two and one-half times the total primary stationary power of the city. And while our motor trucks may be doing only a small percentage of the total freight business of the country, the best available figures indicate that our passenger cars are making passenger-miles far in excess of the railroads.

IS THERE ENOUGH?

Now, I have given very briefly some of the uses to which gasoline and fuel oil are put in carrying the war work on for us to a successful completion. A big question arises, "Is there enough to go around?" In an admirable paper on the subject, "The Relation Between Gasoline and the Growth of the Automobile Industry," Mr. R. D. Leonard presented a very carefully worked out balance sheet of our production of and requirements for gasoline for 1918.

GASOLINE SITUATION, 1918

PRODUCTION

Crude Production	388,000,000
Crude to Refineries	318,160,000
(Crude in 42's)	
(Average Yield of Gasoline, 21 per cent.)	
Gasoline Produced from Crude	56,000,000
Casinghead Produced (in 50's)	5,000,000
Total Production of Gasoline, 1918, all sources	61,000,000
Refinery Stocks, Jan. 1, 1918	6,000,000
Total Available Gasoline, 1918 (in 50's)	67,000,000

REQUIREMENTS

Domestic—	
Number of Automobiles, 1918	4,500,000
(1917, 4,500,000 + 0 per cent.)	
Average Consumption (per car)	10 barrels
Total Required for Motor Vehicles	45,000,000
Industrial Power, Launches, Lighting, Manufacturing and Tractors	6,000,000
Exports	12,000,000
Total Gasoline Required, 1918	63,000,000
Total Available Gasoline, 1918	67,000,000
Net stocks, Jan. 1, 1919	4,000,000

In view of the fact that the petroleum industry is keyed to the highest pitch to meet without pinching or delay the needs of the nation, the estimate of 388,000,000 barrels crude production, which includes the same rate of increase as that experienced last year over 1916, is conservative. The casinghead production figure is that of last year, and it would not be at all inconsistent with past performances to see a production materially in advance of that given, for natural-gas and crude-oil producers, realizing the national need, are winning every drop of available gasoline that reasonable economy affords.

You will notice that the total available gasoline, including the stocks, is a figure about 67,000,000 barrels, while we have to charge against that about 4,500,000 automobiles having an average consumption of 10 barrels—a total of 45,000,000 barrels; our power launches, gasoline lighting systems, our factories and tractors and so on will take another six million barrels, and our exports, which include an authoritative figure on army and navy consumption, will take about 12,000,000 barrels more, which gives us altogether at the beginning of next year a stock of 4,000,000 barrels—a little less than we had at the beginning of this year.

Now, what next year (1919) and succeeding years will have is something of a problem. We will have 340 submarine chasers, at least, which take about 1500 gallons each per day. We may have 20,000 airplanes, which will require, when they are working at full capacity, at the rate of a million barrels a month. Twenty-five thousand motor trucks and ambulances may require, at their maximum, 500,000 gallons more each month, giving totals which lead us to ask, "Is there anything that can take the place of gasoline?" "Are there any substitutes available?" The man who gets a successful substitute has in prize money alone $100,000 awaiting him. He has more than that in reputation, and certainly more than that in remuneration from other sources.

SUBSTITUTES FOR GASOLINE

There are no satisfactory substitutes for gasoline. The claimants for the name are either too expensive, give too much sooty carbon, are clumsy to handle, are difficult to start, or tend to blow cylinder heads off. Some of them have a corroding effect on the metal with which they come in contact, and none of them is produced in quantity sufficient to propel even 5 per cent. of the motors in use. Alcohol, commercial benzol and coal gas each has its exponents, and each has been tried with some degree of success; but at present each is far from taking the place of gasoline.

The production of alcohol is normally at the rate of 100,000,000 gallons per annum (or about 3½ per cent. of the production of gasoline), at a manufacturing cost of 45 cents per gallon. Besides, alcohol has present technical difficulties. It requires a much higher compression than is commonly used in the auto engine, it is more difficult to start than gasoline, and requires considerably more air than gasoline for its proper combustion.

Benzole for several years has aimed for a place beside gasoline as a motor fuel and has been used quite successfully. It is a very decent auto fuel, too, altho its heat value is about 13 per cent. less per pound than gasoline. Benzole is very rich in carbon, the chemically pure material containing 92 per cent. C and 8 per cent. H, and the commercial distillate which might be available for motors contains still more carbon. For this reason benzole requires more air than gasoline. It has a real advantage over gasoline in that it is not so sensitive to change in the mixture, but, on the other hand, is not so well adapted to high-speed engines on account of its slower rate of flame propagation.

But at this time, even waiving a prohibitive cost, benzole can be considered only as supplementary motor fuel. The entire production of benzole is less than 4 per cent. of the demand for motor fuel and the entire quantity procurable, if all the bituminous coal in the country were cooked in by-product ovens, would be but one-third of the present gasoline supply. However, if we reach the point of gassing a large proportion of our coal, benzole would no doubt become a real factor in the motor-fuel market.

Perhaps of all attempts to replace gasoline recently, coal gas has received the greatest attention and been put to the best use. There are no carburettor troubles with coal gas; an engine using it develops about 90 per cent. of the power available from gasoline (altho the engine must be run at higher speeds), and in certain parts of England, particularly in the neighborhood of Manchester, where the experiment was first tried, charging stations are placed conveniently. Coal gas, however, has its disadvantages. To carry the equivalent of two gallons of gasoline in steel tanks, which have since been abandoned, added a weight of 1000 pounds to the tires; on the other hand, the gas bag, shown in the illustration, while weighing but 60 pounds, is a clumsy and unsightly addition to the car and adds materially to the wind resistance. Gas of certain qualities, however, has possibilities, provided a sufficiently strong light tank can be made. In this connection, the greatest improvement may be looked for along the line of the utilization of the very heavy, easily compressible portions of natural gas which are too light for admixture with crude petroleum distillates, but which could be compressed to the liquid state in tanks holding several times the quantity of fuel now possible to carry in the gas bags.

Kerosene has received a great deal of attention as a possible gasoline substitute. Kerosene is a very excellent fuel. It is doing splendid work in this country in many engines. It has nearly as high calorific value as gasoline, pound for pound. But gasoline is preëminently the high-speed fuel; it is flexible. The engine in a motor car does not give any fuel much more than, if it gives as much as, one-thousandth of a minute for complete combustion—a time which we have found so far is quite inadequate for the complete combustion of the comparatively large globules of heavy fuel which we are able to get thru an ordinary carburettor, and even thru the modified carburettor using the preheating principle. Nor does excessive heating, with the object in view of more nearly complete volatilization of the kerosene, avail much, for

MR. ASQUITH'S WOLSELEY LANDAULETTE, EQUIPPED WITH THE LYON-SPENCER GAS-CONTAINER.

at very elevated temperatures the process of decomposition—so useful in permitting the more volatile petroleum products to rapidly undergo combustion—here sets in and with compounds of higher molecular weight gives use to such appreciable quantities of very viscous, tarry and coke-like substances as soon to impair the operation of the carburettor and clog the passages. In other words, we endeavor to make gasoline right on the machine—we put our fuel thru a "cracking" process and have exactly the results which make cracking always a problem of equipment upkeep.

It is speed, then, that determines the need for volatile rapid-fire fuels, and to change the motor speeds means to change the entire design and construction of the car. The Force × Distance = Work equation explains simply the whole performance. The internal combustion engines of the 1870-1885 period were of slow speed, and weighed from 1200 pounds to 1800 pounds per horsepower. Today we have perfected valve timing and ignition design to enable the manufacture of engines capable of developing a horsepower for every 2½ pounds to 3 pounds of metal—made possible by rapid combustion and great piston speeds. It is true that thousands of engines operate day in and day out on fuels much heavier than kerosene, but not many motorists would care to carry in their car a 10,000-pound motor whose performance and ability would not exceed their 400-pound motor.

The work of the research laboratories of the future must prove the point, but at this time it appears wiser to crack the heavier hydrocarbons in a specially built plant with facilities for the subsequent refining of the volatile resultants, and continue to use light high-speed engines, than to attempt slower engines or fouling decompositions on the car.

I mentioned that alcohol and benzole were difficult to start. Also that alcohol and benzole were fairly uniform products, possessing nearly constant boiling points, whereas gasoline distils over a rather wide range, some of its constituents boiling at blood heat. I mentioned also the greater flame propagation rate of gasoline. Now it has one other desirable property; its constitution is such that a very small quantity only, in an air mixture, produces an explosion. Consequently, on a cold morning, with this complex mixture in the carburettor, a turn of the crank, whether by hand or electric machine, sends a small quantity of that very light end of the gasoline into the engine cylinders—a sufficient quantity, however, in view of the small quantity required, to form an explosive mixture and start our engine.

Let me say, in concluding this phase of our subject, that what we need is, not so much a manufactured substitute for the great quantities of concentrated power which nature has given us in the lighter portions of crude petroleum and in the condensates of natural gas, but a material improvement in the total efficiency of our machines. Improve that total efficiency but 10 per cent. and without adding another gallon to our production we can operate 10,000,000 motor cars on the same basis as we operate 5,000,000 today.

FUEL OIL SITUATION, 1918

Is there enough fuel oil? Fuel oil is needed in prodigious quantities. A torpedoboat destroyer when working at full speed will need at the rate of about 50 barrels an hour; a battleship of the first class, at the rate of about 150 barrels an hour, or at the rates of about 20,000 and 60,000 barrels a month respectively. But we have greater yields and larger supplies of fuel oil than we have of gasoline, by far, to take care of the demands made for this liquid fuel, and increasing yields are being wrought from well and still. In 1916 the yield of fuel oil direct from the well was at the rate of about 17 per cent.; last year it was at the rate of 11 per cent., showing us that we are, or at that time we were (in 1917), endeavoring to conserve more of the more valuable constituents of our crude before having a residue to use as fuel. In 1916 from the crude that was left after taking about 40,000,000 barrels for fuel, we obtained fuel oil at the rate of 45 per cent. of all oil run in the refineries. (See table.) During the first nine months of 1917 we obtained oil at the rate of 50 per cent., and for the third quarter at the rate of 54 per cent.—a figure which I have used in the estimate. If we continue this year at last year's rate we will have direct from the well, after settling for abstraction of water, sludge, and dirt, 42,000,000 barrels of crude oil to use directly as fuel, and we will have 186,800,000 barrels of fuel oil which we will obtain from the refineries after the abstraction of the more valuable constituents.

FUEL OIL SITUATION, 1918

(Barrels of 42 Gallons)

PRODUCTION

Crude Production	388,000,000
Crude to Refineries	346,000,000
Fuel Oil from Crude (Refined—54 per cent. Yield)	186,000,000
Fuel Oil—direct from Crude (Unrefined)	42,000,000
Total Production in U. S.	228,800,000
Stock, December 31, 1917	13,760,000
Total Available—1918	242,560,000
Mexican Production, 1917	60,000,000
Mexican Imported, 1917	35,000,000

REQUIREMENTS

Exports	32,000,000
Gas Works (Carburetting Water Gas)	17,000,000
Railroads	50,000,000
Industrial and Maritime Uses Heat treating and Other Special Furnaces Stationary Steam Plants, Merchant Marine, Stationary Internal Combustion Engines.	*90,000,000
Emergency Fleet Program	6,000,000
Total Known Requirements, exclusive of Navy	195,000,000
Balance Available for Navy	33,800,000
Total	228,800,000

* Exclusive of consumption of Mexican Oil.

This chart, which is built somewhat on the basis of the previous chart, shows a crude production of 388,000,000 barrels, of which the refineries will obtain 346,000,000 barrels, giving, at the rate of 54 per cent., a yield of 186,800.000, and directly from the crude some 42,000,000 barrels, or a total of 228,800,000 barrels. The stocks, which it may be well to maintain to steady the supply, at the beginning of the year were 13,760,000 barrels. Now the consumers of this oil, who are placed on the right side of the chart, are, to the extent of 32,000,000 barrels for this year for export—our Allies' navies and merchant marine—the gas works, for the carburetting of water gas—about 17,000,000 barrels. Our railroads, if they continue at the rate of previous years, will use 50,000.000 barrels. For industrial purposes, heat treating of steel, steam-generating plants, merchant marine, internal-combustion engines, etc., about 90,000,000 barrels. (Now these figures are simply consumptions against the United States production.) The Emergency Fleet program will use at least 6,000,000 more—a total of 191,000,000 barrels, which, from our total production of 228,000,000 barrels, leaves us available for the navy 37,800,000 barrels. The navy, of course, will get what it wants, whether it wants three or four times that quantity; but 37,800,000 barrels is no mean quantity of fuel oil. It is about 33 times the quantity that the navy used in the year ending June 30, 1916; and it is sufficient to supply for one year fifty torpedoboat destroyers and twenty large battleships. Some time ago our oil-burning units in the navy were about 11 battleships and some 43 destroyers. However, the increases in the activity of our fleet and the additions of oil-burning equipment to our navy may demand all of that and some more.

Now, down at the left of the chart you will notice the Mexican production, in 1917, of about 60,000,000 barrels, of which about 35,000,000 were imported into this country. A large part of the industrial and maritime users of fuel oil—particularly in the New England field, where some 5,000,000 barrels of oil were used under boilers for steam purposes alone—were supplied from this source. The complete requirements of the several consumers, you will notice, have been taken from our own production, so that if the Mexican petroleum is available this year as it was last, and continues to be available, we shall have sufficient oil to take care of our ordinary requirements and all of our extraordinary war needs.

THE EUROPEAN FIELDS

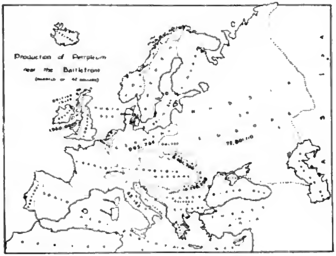
An appreciation of the importance of petroleum, gasoline and fuel oil particularly, in the conduct of the war, makes us give increased significance to the movements of Germany toward the oil fields.

CRUDE OIL PRODUCTION IN 1916

(Barrels of 42 Gallons)

United States	300,767,158	65.29
Russia	72,801,110	15.81
Mexico	39,817,402	8.64
Dutch East Indies	13,174,399	2.86
Rumania	10,298,208	2.24
India	8,228,571	1.79
Galicia	6,461,706	1.40
Japan and Formosa	2,997,178	.65
Peru	2,550,645	.55
Trinidad	1,000,000	.22
Germany	995,764	.22
Argentina	870,000	.19
Egypt	411,000	.09
Canada	198,123	.04
Italy	43,143	
Other countries	25,000	.01
	460,639,407	100.00
British Isles (from shale) 1915	1,960,000	

You will recall that early in the war Russia swooped down on Galicia, Austria-Hungary, and occupied for some weeks the rich oil country; that later they lost this advantage; and that loss meant a great deal to Germany and a great deal to us. We will revert to this in a moment. In 1916, according to the United States Geological Survey, the productions of the more important petroleum-producing countries were, as shown by the chart: The United States produced over 65 per cent. of the total of the world. Russia, with 73,000,000 barrels, was second. Mexico came third, with about 40,000,000. Then you will notice the Dutch East Indies, Rumania, India, Galicia, Japan, Peru, Trinidad, and Germany follow in order, Germany's production being comparatively insignificant. But Galicia's production is important, being normally about 8,000,000 barrels, and Rumania, similarly, with about 12,000,000 barrels production annually, has been a real factor in the European oil situation.



The map shows the production of petroleum in the battle territories. The East Indies are pretty far off. We are pretty far off. We had other than war uses for most of our material all during the early years of the war, prior to April 6, 1917. The producing countries around the battle zones are: Germany, with about a million a year; Galicia, as I indicated, with about 8,000,000 a year normally—the figure for 1916 was 6,461,000, which was below normal, but is immensely more than it was shortly after the firing and dynamiting of wells in the Russian retreat. [The Germans subsequently put out the fires, cleaned out the drill holes where possible, and brought the production fairly well up to normal.] Rumania, with a production in 1916 of over 10,000,000, and Russia with nearly 73,000,000. Italy's 43,000 barrels do not count heavily.

In the British Isles we have a production of "shale oil" of nearly 2,000,000 barrels of oil—1,960.000 barrels in 1916, approximately. That figure in the chart is estimated on the previous year's output.

PETROLEUM WAR STRENGTH OF ACTIVE BELLIGERENTS

(Early in the War—About January 1, 1915)

(1915 Production)

ALLIES		CENTRAL POWERS	
Russia	68,548,062	Germany	995,764
Galicia	4,158,899		
India	8,202,674		
British Isles (shale oil)	1,960,000		
Total	82,869,635	Total	995,764

About January 1, 1917

(1916 Production)

ALLIES		CENTRAL POWERS	
Russia	72,801,110	Germany	995,764
Rumania	10,298,208	Galicia	6,461,706
India	8,228,571		
British Isles (shale oil), 1915	1,960,000		
Total	93,287,889	Total	7,467,570

At Present, May 15, 1918

(1916 Production)

ALLIES		CENTRAL POWERS	
United States	300,767,158	Germany	995,764
India	8,228,571	Galicia	6,461,706
British Isles (shale oil), 1915	1,960,000	Rumania	10,298,208
Total	311,055,729	Total	17,755,678

When Russia occupied Galicia in the early days of the war the Allies had added to their production in the vicinity of the battle fields Galicia's output, and conversely decreased the enemies' resources by the same amount.

At this time, then, the total resources of the Central Powers, with the loss of Galicia, was only one million barrels.

By the first of January, 1917, the situation had changed. Russia had lost Galicia; Rumania had become one of the Allies. The Allies gained direct control, therefore, of ten million barrels' production, bringing the total up to about 93,000,000; but the total for the Central Powers increased more than sixfold, giving a total of about 7,500,000 barrels; and a little later, or taking about the middle of May, 1917, the 1916 production figures being used, the United States had been added to the Allies, with its 300,000,000 barrels. The Indian production was 8,000,000 barrels and the British Isles is still taken at about 2,000,000—a total of over 310,000,000 barrels. But, of course, a large part of those 300,000,000 barrels of American production had been previously available for the use of the Allies.

Now, on the other side, we have the German production of about a million barrels and the Galician production, now raised to 6,500,000 barrels, and finally by the

Rumanian Treaty there was available to Germany another 10,000,000 barrels, or a total of about 17,000,000 barrels.

What Germany is going to do in Russia is problematical, but if she gains complete control, as seems possible, excepting immediate Allied intervention, 68,000,000 or 70,000,000 barrels may be added to her resources.

The important thing in these comparisons is not that the gross petroleum resources of the Germans or Central Powers is much greater or of ourselves and our Allies less, but that from almost no resources, at which point they must have been vigorously stressed for supplies for airplanes, for supply trucks, for submarines and for munition plants—from almost nothing our enemy has gradually acquired sufficient to take care of a great many of her needs.

Now, what does the future hold forth? What 1919 and succeeding years may bring I have not attempted to estimate in detail. So far as can be seen, we have ample to take care of our industrial and our war needs, unless the war is of very much longer duration than most of us believe it will be. We are going to have greater demands, of course; Our ships are being rapidly completed. It is altogether possible that next year our emergency fleet and our merchant marine will require 35,000,000 to 50,000,000 barrels of fuel oil. Our Navy Department forces will require more than they are using at this time. Our industries will naturally use more than they are using today, due to natural increase, if thru no other cause. Have we enough to take care of all these needs? The petroleum resource of the country, according to statements made by the Director of the Bureau of Mines, Dr. Van B. Manning, amount to about eight billion barrels—an amount larger than the total consumption of the country during all the days of the petroleum industry since the first flow of oil at the Drake well, in 1859; but he estimates also that if we continue at the present rate of consumption this eight billion barrels will last us only 29 or 30 years. However, in the Colorado-Wyoming district alone it is estimated that there are fully twenty billion tons of oil shale available for the production of bituminous materials—light products, fuel oils, lubricating oils, and so on; and this twenty billion tons of shale will yield twenty billion barrels of good quality oil by a process which has been commercially successful in Scotland for more than 40 years. And when we think of Spindle Top and the enormous gushers recently loosed in Mexico, we are reminded that perhaps the very greatest strikes still await the driller.

LABOR AND CAPITAL*

By HARRY TIPPER

Business Manager, "Automotive Industries," New York City.

History of the labor problem; variance between the ideals of labor and capital; political, industrial and social aspects of the question.

I HAVE chosen the subject of the labor problem, altho there is no labor problem abstractly; there is a mass problem. So long as we deal with it as an abstract—mass matter—we shall not approach the problem in any way. Neither is it a problem which has just opened to us in the war. It has been existent for a century, transferring from an individualistic craftsman's organization into a mass organization of industry. We have learned thru the centuries up to the nineteenth century to lay down a code of laws for the individual, to deal industrially individually, to deal as man to man, but we are only beginning to learn something of the dealings of responsibility of mass to mass in industrial operations. It is impossible to study the labor problem of to-day without understanding the history of the labor problem of yesterday. The war has developed the labor problem; it has also developed the labor ideal, and it has brought the question of the ideal of labor and the ideal of the government of industry much closer to us and made it much more necessary of solution.

We have seen in this war the force which is given to an applied ideal. Now, no matter whether the ideal be a right ideal or a wrong one, if it is sufficiently accumulated by the mass of people it will in the course of time acquire an operating force and begin to roll. Even the terrific ideals of the German people have, in time, acquired such a unity and operating force that they have been bound to roll in a certain direction. The ideal of labor has been the labor union, the only possible ideal for the mass labor. The ideal of the individual craftsman was the ideal of accomplishment—the job. The ideal of industry has been profit. Between the ideal of labor, as to its hours and remuneration, and the ideal of industry as to profit, there is not and never has been a common ground or meeting place. From the very beginning of the transfer of industry to the factory system, industry has always exploited labor to the maximum of its capacity, and labor has always gained what it did by force. Those two things must be thoroly understood in order to approach this problem. So long as the profits of industry and the profits of labor are the only ideals of industry on the one hand and labor on the other, so long must the question of difference be solved by strife only; for, unless we displace the ideal of the present with the ideal which can be used in the future for better purposes; unless we get into our work the spirit of accomplishment on both sides, instead of the spirit of profits, we shall continue until we get into either a labor or industrial autocracy. And as this has been brought nearer it is evident that the labor problems have been met during the war. Mr. Schwab himself said, not long ago, something which a few years ago would have been stamped as the rankest socialism, when he said that the worker would rule before very long. The Standard Oil Company, one of the most autocratic concerns in this country, but at the same time one of the most intelligent, began the other day an experiment in democracy in industry. It was arranged that representatives of the workers should sit with the Board of Directors to consider wages, factory conditions and other essentialities of the working man. The platform of the British labor party as adopted by it about three months ago is one of the clearest, shrewdest and most practical documents ever issued by any political party, and no matter whether you agree or disagree with its provisions, you must admire the strength of its language and the character of its work.

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* Delivered at the Annual Dinner of the Pennsylvania Section, Society of Automotive Engineers, May 25, 1918, Hotel Adelphia, Philadelphia.

In England in the war industries controlled by the Government it has been necessary to put committees in charge of those industries representing both labor and capital.

At the same time, we have in this war made a living thing out of the dead ideal of democracy. We have made it a living thing not in the minds of a few people but in in the minds of millions of people. It will be made such a living thing that millions of people will work with no prospect of advancement in money, no prospect of profit, no other incentive than democracy. When that ideal, resuscitated like that, comes upon us after the war, what effect is it going to have on our industrial relations? How are we going to treat labor as an abstract question, when the ideal of democracy, the ideal that has been expressed thru this very sacrifice of war, comes up as a matter of the industrial relations—the work of ninety per cent. of the waking hours of the population? Are we to say that labor will be plentiful; that we can go back to the old scheme of industrial transactions and exploit the worker as we have done? Are we to say that he who has fought for a voice in the affairs of government shall have no voice in the affairs of industry? Is it possible for a government to live which is democratic politically and autocratic industrially, when it has been impossible for two governments to live side by side when one was democratic politically and the other autocratic politically? Shall we deal with this purely as an economic question, or are we alive to the fact that the force of idealism in the labor movement—for it is the force of idealism that came to it directly from the transfer into the factory —are we to recognize the fact that this force of idealism has accumulated such growth in the century of factory work that it is almost ready to roll on? Or, are we simply to sit back and say it will right itself; we cannot have any interference with our industry; it is our private property; it is our work; we must adjust it as we like in that particular field?

I had the privilege when a boy of watching in a town, which was seventy-five years behind the times, the transfer of hand-work into industry, and that delightful mission gave me an interest in the worker that I might not otherwise have had. I saw workers who had contracted for the cloth to be woven in their own homes, and in their cottages, transferred to the mill. I saw them get the same pay in the mill as they made out of their contract work, but in addition to their pay in their contract work they had been able to weave the cloth for the family. They had been able to attend to their gardens, and while their hours had been long, working from light until dark, they had not been obliged to sit at the machine all the time; whenever their backs hurt they could get up and recuperate. When they were transferred into the mill they received no more pay in the mill and could not make the cloth for their family and could not get the expense out of the garden. The whole family was transferred into the mill to meet the expense.

Now, the individuality of the workman was lost; the individual design and construction of the cloth by the contract worker was lost; he became nothing but a machine with two ideas in his head, namely, how to decrease the hours and how to increase the pay; and that was the beginning of the labor union ideal, and we have constructed no other ideal. Until ten or fifteen years ago we did not try to raise a company ideal or a department ideal or organization ideal. It has only been since the war has come on that we have been shown that an ideal is the greatest operating force. The incentive is greater than anything else. We have to recognize that industry requires ideals just as well as politics, and that politics and industry must accumulate and accommodate themselves to suit the same range of ideals.

It is not for nothing that the only complete autocracy—Germany—has had a more complete unity in the beginning than any other autocracy, because the system was the same industrially, politically and socially. In all the other countries there was a division between industry and politics. The man who had the power in politics had it taken away from him. He lost it industrially. And, unless we watch, compromise, understand what it means, he is going to have it taken away from him now industrially. He is going to get the socialistic state toward which he has been drifting. I had a letter from a prominent man in London the other day in which he said, "There is no doubt in our minds that the reconstruction of England after the war will be in the hands of the labor party." That is the strength of the labor party in England. We have not reached that point here, but the same forces are at work here as there, and it all depends on the vision of the manufacturers—the vision of the industrial engineer, for the engineer after all should have the vision as to the rights, obligations, possibilities of the individual man on the labor questions, as to whether we enlarge our vision by intelligent compromise, or destroy our civilization by unintelligent force to strive between the two. The conservative, intelligent labor leaders in England will admit to you, if you get close enough, that they have all they can do to keep the radical labor leaders in line at this present moment; that only the unity of the supreme necessity of war keeps the labor union conservative, and when that unity is passed over and the necessity is no longer there then the whole radical element of the labor party in some way or another will begin its work as in the past with more power, force and energy because of the recrudescence of these American ideals. So that, in times like these, when you have this unity in labor and labor is scarce, we are troubled with the problems of getting men when we are competing with each other, and do not know what our constant is going to be—this is the time when we will have to study labor as we have never studied any business before. If we put half the study on labor that we put on a question of engineering equipment we shall be very much further along than we are to-day, but there are very few men in business who have studied the history of the labor union—its growth, its necessities, the character of its organization, or its possibilities for mass action in the future, and the way in which that mass action can be used to better industry instead of to destroy it.

That is all that can be said in a moment of time. The subject ramifies. It cannot be taken up merely from the standpoint of economics. It is not economic. Its principles are philosophic, its processes psychologic, and its results economic; but if you deal with only economics you cannot possibly solve it.

ELECTRIC WELDING AS APPLIED TO STEEL SHIP CONSTRUCTION

*A series of discussions held under the auspices of the Electric Welding Branch of the Education and Training Section of the U. S. Shipping Board, Emergency Fleet Corporation.**

INTRODUCTION

By H. A. HORNOR, Member

IN March of this year the Emergency Fleet Corporation appointed a special committee to investigate and advise the Corporation on the status of the art of electric welding and its possible employment in hastening the completion of the steel ship program. Prof. Comfort A. Adams was selected as Chairman of this Committee, not only because of his long study of the subject, but also on account of his energy in organizing a similar committee as a sub-committee of the Research Committee of the American Institute of Electrical Engineers. This original Committee had already gathered a great deal of important data and had arranged with the U. S. Shipping Board for the visits of Captain Caldwell to this country for the purpose of explaining the methods and extent of the application in Great Britain.

One of the earliest suggestions of the Electric Welding Committee was the necessity for trained operators, and the Emergency Fleet Corporation, acting upon this suggestion, added a Branch for the study of this subject to the Education and Training Section. The main purpose of this work is to provide skilled men to the shipbuilders, not only for the performance of good welding, but to act as instructors for other workmen.

It was early recognized that the operator, altho most important in the actual making of a good weld, required something far more important back of him in the accomplishment of perfect joints in the steel structure of a vessel. No man on the Welding Committee to-day fails to realize that the joining of the essential parts of a ship is a vital and serious question. On the other hand, no member of the Committee doubts that, if these joints are designed after careful study by the naval architect, the engineer, and technician, the application can be made most successfully with a resultant of increased speed of construction. With this in mind, the Fleet Corporation desired to discuss all the questions connected with this subject with the technicians of the shipbuilding industry in order that no detail, no matter how minute, should escape complete investigation before this industry broadened its field of action. Therefore, a program was prepared to cover in general the entire subject and to encourage a full consideration of the details involved.

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* The executives of the Education and Training Section of the Emergency Fleet Corporation at the present time are as follows: Director, Mr. Louis E. Reber; Superintendent of Training, Mr. E. E. MacNary; Head of Electric Welding Branch, Mr. H. A. Hornor.

A cursory glance at this program will show that the fundamentals of the art had not been grouped in any specific order, and that no symbols had been adopted so that drawings of a comprehensive nature could be prepared. The first discussion consists of an explanation of the proper nomenclature and symbols that have now been approved as standard by the Electric Welding Committee. The language, having once been introduced, the investigator turns naturally to the tools which are now available for performing the work. This forms the subject of the second discussion. With these two important factors, the third discussion naturally turns to the advantages that may be gained in their use in the construction of the steel ship. This latter subject applies both to the present riveted ship and the future ship that may be more largely welded, a subject discussed in the fourth and fifth meetings. The sixth discussion makes a summary of all the preceding ones and emphasizes the essential points dealing with the successful application of electric welding in steel ship construction.

First Discussion

NOMENCLATURE FOR ELECTRIC WELDING*

By NAVAL CONSTRUCTOR H. G. KNOX, U. S. N.

IT is evident to all persons interested in the nomenclature of welding that, if we are to avoid confusion and retarded progress, we must all talk the same language in discussing the same thing. A typical example of the result where the design followed the actual working conditions is found in the city of Brooklyn, New York, where, I understand, Fulton Street was laid out along an old cow-path leading up from the ferry. As a consequence of this system of layout, it is very confusing to get about that city. The city of Washington, on the contrary, was laid out after considerable scientific study and based on the competitive designs of architects. In this case, the development followed after the design and the result is very much more satisfactory. As a further illustration, you are reminded that the actual working steam engine was in use years before anybody dreamed of thermo-dynamics, while electricity, following its discovery by Benjamin Franklin, was entirely a laboratory product until the standardization in nomenclature and the theory of the subject had been pretty well worked out. As a result, electricity is a most satisfactory science to work in because all the terms are clear and concise, and I think we owe a great debt to the electrical engineers for their remarkable work in the standardization of their rules.

STANDARD SYMBOLS

It is also necessary in welding that at the outset we adopt a uniform terminology. It was early suggested at one of the meetings of the Welding Committee that we divide all types of welded joints into several main classes, and that a mnemonic symbolism for each be adopted. First, under this classification would come the type of joint, such as the butt, the jog, the lap, the Tee and the strap. The mnemonic symbol proposed was for the butt joint the symbol B, the jog, J. the lap, L, the Tee, T, and for the strap, S.

Next in point of continuity of the complete mnemonic system of symbols are the various types of weld. First, come the foundation or base weld, which is the first run put at the bottom of a heavy V, next, the bolt weld, then the edge weld, the fill weld, the plug weld, the seam weld, the tack weld, and the special types of weld. To illustrate: a joint called a lap filled double tack would, under the mnemonic system, be represented by the symbol L F K K. Since such a notation would be a great deal of bother for the draftsman, we have formed other classifications, and the mnemonic system was abandoned in favor of a more nearly symbolic notation, in which certain symbols, and, in some cases, numbers, have been used with the result that the designations are more easily placed on the drawings.

INSTRUCTION CHART WITH STANDARD SYMBOLS

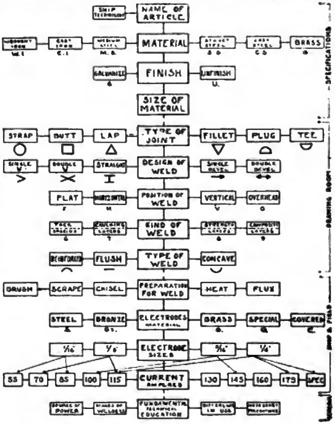

Figure 1 shows the first page of the instruction chart illustrating the finally adopted symbols. In the first group are the points which should be covered by the general specifications. The second group shows the design, the position of the weld and the type, and this the draftsman must use. There is here a slight similarity in the use of terms that later may be modified for the sake of clearness. Group three will be embodied later in a Handbook for the shop, and will cover the material and size of the electrodes, the current and other necessary information for the guidance of the operator.

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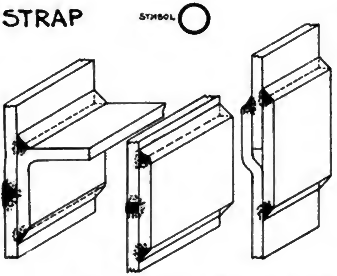
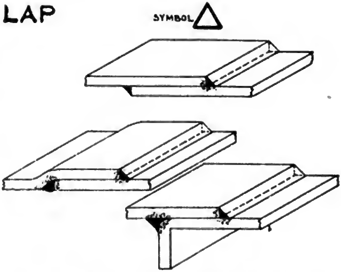
* Delivered in the Auditorium of the Engineers' Club of Philadelphia, Wednesday evening, June 26, 1918.

TYPE OF JOINT

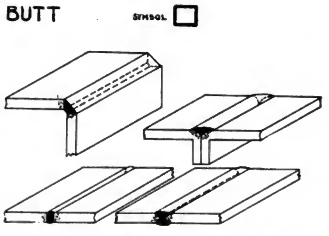
Figures 2 and 3 represent one of the design subdivisions, namely, the type of joint. These joints are all familiar to shipbuilders. Three characteristic types of the strap joint are shown in Figure 2; on the left, is an ordinary strap joint in which the joint is backed up by an angle; in the centre, an ordinary strap; and on the right, a joggled strap. All strap joints are symbolized by the circle. All the other symbols which go to tell the complete story of the weld are placed inside that circle, as will be explained later. Next is the butt joint, and is denoted by the square. On the upper right is a type of joint, which, in the original nomenclature, was called a flanged butt. Then comes the lap joint, which is denoted by the triangle, with the apex up, and under this type is



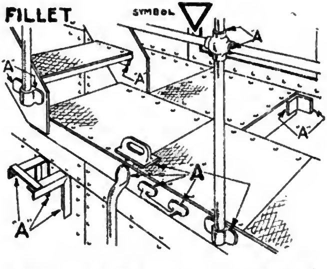
STRAP weld is one in which the seam of two adjoining plates or surfaces is reinforced by any form or shape to add strength and stability to the joint or plate. In this form of weld the seam can only be welded from the side of the work opposite the reinforcement, and the reinforcement of whatever shape must be welded from the side of the work to which the reinforcement is applied.



LAP weld is one in which the edges of two plates are set one above the other and the welding material so applied as to bind the edge of one plate to the face of the other plate. In this form of weld the seam or lap forms a raised surface along its entire extent.

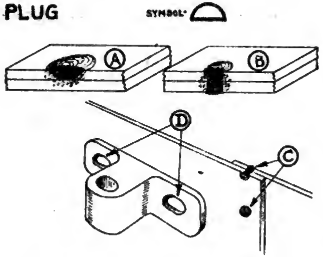


BUTT weld is one in which two plates or surfaces are brought together edge to edge and welded along the seam thus formed. The two plates when so welded form a perfectly flat plane in themselves, excluding the possible projective caused by other individual objects, as frames, straps, stiffeners, etc., or the building up of the weld proper.

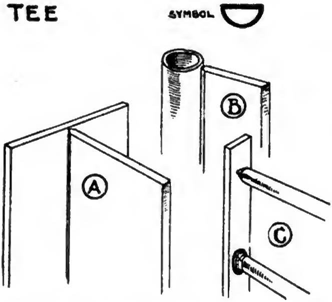


FILLET weld is one in which some fixture or member is welded to the face of a plate by welding along the vertical edge of the fixture or member (see "welds" shown and marked "A" on illustration at left). The welding material is applied in the corner thus formed and finished at an angle of forty-five degrees to the plate.

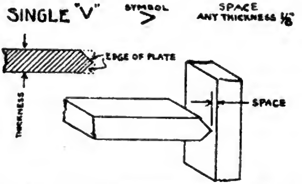
shown the plain lap, the joggled lap and the flanged lap. Of the three other types of joints (see Fig. 3), the first is called a fillet joint; the second, the plug joint, and the third, the Tee joint. The fillet joint is rather hard to define other than by reference to these sketches, but it is the weld that is made around fittings to plates and its use will be perfectly clear whenever the occasion arises. It is denoted with a triangle with the apex down. The plug joint is the weld used where it is necessary to join one plate to another by means of punching or otherwise making a hole in one plate, such as for service-bolts or other forms of preliminary bolting up work, which later requires filling in. It also applies to welds thru holes in forgings used in securing the forgings to plates. The symbol in this case is a half circle and straight line, convex side up. The Tee joint, which is shown in two or three typical forms, is denoted by a half circle with the convex side down.



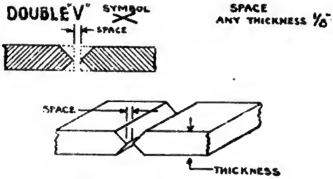
PLUG weld is one used to connect the metals by welding thru a hole in either one plate (Fig. "A") or both plates (Fig. "B"). Also used for filling thru a bolt hole as at Fig. "C," or for added strength when fastening fixtures to the face of a plate by drilling a countersunk hole thru the fixture (Fig. "D") and applying the welding material thru this hole, as at Fig. "D," thereby fastening the fixture to the plate at this point.



TEE weld is one where one plate is welded vertically to another, as in the case of the edge of a transverse bulkhead (Fig. "A") being welded against the shellplating or deck. This is a weld which in all cases requires EXCEPTIONAL care and can only be used where it is possible to work from both sides of the vertical plate. Also used for welding a rod in a vertical position to a flat surface, as the rung of a ladder (Fig. "C"), or a plate welded vertically to a pipe stanchion (Fig. "B"), as in the case of water-closet stalls.



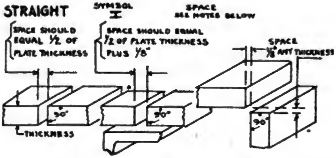
SINGLE "V" is a term applied to the "edge finish" of a plate when this edge is beveled from BOTH sides to an angle, the degrees of which are left to the designer. To be used when the "V" side of the plate is to be a maximum "strength" weld, with the plate setting vertically to the face of an adjoining member, and only when the electrode can be applied from both sides of the work.



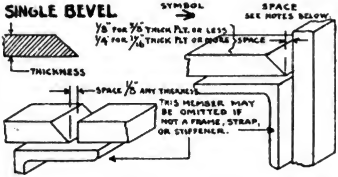
DOUBLE "V" is a term applied to the "edge finish" of two adjoining plates when the adjoining edges of both plates are beveled from BOTH sides to an angle, the degrees of which are left to the designer. To be used when the two plates are to be "butted" together along these two sides for a maximum "strength" weld. Only to be used when welding can be performed from both sides of the plate.

DESIGN OF WELD

We now come to the weld itself. The first design, Fig. 6, is the Single V, and its symbol is the letter "V" placed on its side. The application of the V is obvious. As a matter of fact, the V joint is very largely confined to heavy plates where they are accessible on both sides and is closely related to the bevel design below. The Double V is used in joining plates or forgings, and is applied in the case of joints in heavy plates where the plates are accessible from both sides. In very heavy plates a successful type of joint may be made by using small triangular filler pieces, thereby reducing the electrode material. The Straight Weld, with the symbol of a modified " I," or " H " placed on its side, is used only for light plates, because the arc is unable to get down between thicker plates and make a good weld at the bottom. If it were attempted to use the arc in a deep, straight-sided opening with a bare electrode, it would jump from side to side and off the body of the electrode rather than off the point. It is necessary, where this joint is used, to vary the space between the edges of the plate, depending upon the thickness of the plate. The Single Bevel is in some ways an unusual joint, not as common as the Double Bevel, but it has its uses, particularly in horizontal seams. It is also claimed to be more economical from the machining point of view, because only one plate edge is machined.

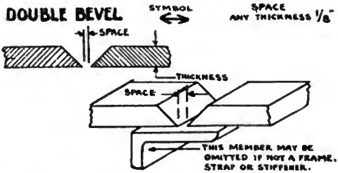

STRAIGHT
SYMBOL
I
SPACE
SEE NOTES BELOW
SPACE SHOULD EQUAL ½ OF PLATE THICKNESS
SPACE SHOULD EQUAL ½ OF PLATE THICKNESS PLUS ⅛"
SPACE
⅛" ANY THICKNESS
90°
90°
90°
THICKNESS

STRAIGHT is a term applied to the "edge finish" of a plate, when this edge is left in its crude or sheared state. To be used only where maximum strength is NOT essential, or unless used in connection with strap, stiffener or frame, or where it is impossible to otherwise finish the edge. Also to be used for a "strength" weld when edges of two plates set vertically to each other—as the edge of a box.


SINGLE BEVEL
SYMBOL
→
SPACE
SEE NOTES BELOW
⅛" FOR ⅜" THICK PLT. OR LESS
¼" FOR 7/16" THICK PLT OR MORE
SPACE
THICKNESS
SPACE ⅛" ANY THICKNESS
THIS MEMBER MAY BE OMITTED IF NOT A FRAME, STRAP, OR STIFFENER.

SINGLE BEVEL is a term applied to the edge finish of a plate when this edge is beveled from ONE side only to an angle, the degrees of which are left to the designer. To be used for "strength" welding when the electrode can be applied from ONE side of the plate only, or where it is impossible to finish the adjoining welding surface.

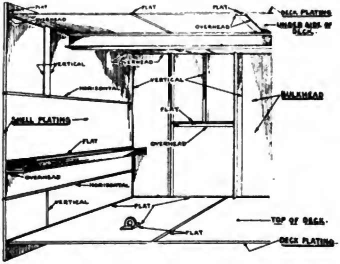
The double bevel joint is probably the one that will be most employed in ship construction. The symbol for the single and double bevel is the single and double arrow.


DOUBLE BEVEL
SYMBOL
↔
SPACE
ANY THICKNESS ⅛"
SPACE
THICKNESS
SPACE
THIS MEMBER MAY BE OMITTED IF NOT A FRAME, STRAP OR STIFFENER.

DOUBLE BEVEL is a term applied to the edge finish of two adjoining plates when the adjoining edges of both plates are beveled from ONE side only to an angle, the degrees of which are left to the designer. To be used where maximum strength is required, and where electrode can be applied from ONE side of the work only.

POSITION OF WELD

In arc welding the position of the weld makes a great difference. Fig. 13 shows the four different posi-



FLAT position is determined when the welding material is applied to a surface on the same plane as the deck, allowing the electrode to be held in an upright or vertical position. The welding surface may be entirely on a plane with the deck, or one side may be vertical to the deck and welded to an adjoining member that is on a plane with the deck.

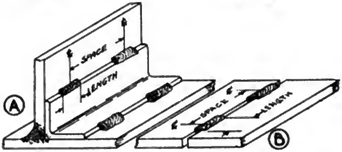
HORIZONTAL position is determined when the welding material is applied to a seam or opening the plane of which is vertical to the deck and the line of weld is parallel with the deck, allowing the electrode to be held in an inboard or outboard position.

VERTICAL position is determined when the welding material is applied to a surface or seam whose line extends in a direction from one deck to the deck above, regardless of whether the adjoining members are on a single plane or at an angle to each other. In this position of weld the electrode would also be held in a partially horizontal position to the work.

OVERHEAD position is determined when the welding material is applied from the under side of any member whose plane is parallel to the deck and necessitates the electrode being held in a downright or inverted position.

TACK

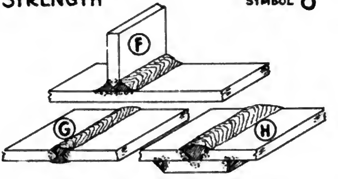
SYMBOL·6·



A TACK weld is applying the welding material in small sections to hold two edges together, and should always be specified by giving the SPACE from centre to centre of weld and the LENGTH of the weld itself. No particular "design of weld" is necessary of consideration. A TACK is also used for temporarily holding material in place that is to be solidly welded, until the proper alignment and position are obtained, and in this case, neither the LENGTH, SPACE, nor DESIGN OF WELD is to be specified.

STRENGTH

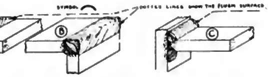
SYMBOL·8·



A STRENGTH weld is one in which the sectional area of the welding material must be so considered that its tensile strength and elongation per square inch must be equal at least to 80 per cent. of the ultimate strength per square inch of the surrounding material. (To be determined and specified by the designer.) The welding material can be applied in any number of layers beyond a minimum specified by the designer.

The density of the crystalline metals is NOT of vital importance. In this form of weld, the "design of weld" must be specified by the designer and followed by the operator.

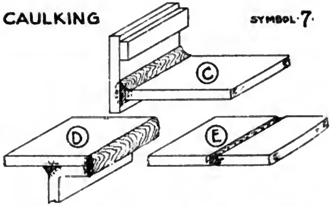
REINFORCED



REINFORCED is a term applied to a weld when the top layer of the welding material is built up above the plane of the surrounding material as at Fig. "A" or Fig. "B" above, or when used for a corner as in Fig. "C." The top of final layer should project above a plane of 45 degrees to the adjoining material. This 45-degree line is shown "dotted" in Fig. "C" above. This type is chiefly used in a "Strength" or "Composite" kind of weld for the purpose of obtaining the maximum strength efficiency and should be specified by the designer, together with a minimum number of layers of welding material.

CAULKING

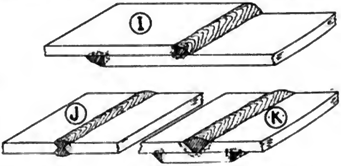
SYMBOL·7·



A CAULKING weld is one in which the density of the crystalline metal used to close up the seam or opening is such that no possible leakage is visible under a water, oil or air pressure of 25 pounds per square inch. The ultimate strength of a caulking weld is not of material importance; neither is the "design of weld" of this kind necessary of consideration. The operator must be the judge in the number of layers needed for a tight weld, altho the designer should specify a minimum amount of layers.

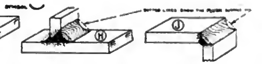
COMPOSITE

SYMBOL·9·



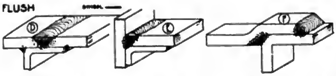
A COMPOSITE weld is one in which both the strength and density are of the most vital importance. The STRENGTH must be at least as specified for a "strength weld," and the density must meet the requirements of a "caulking weld" both as above defined. The minimum number of layers of welding material must always be specified by the designer, but the welder must be in a position to know if this number must be increased according to the welder's working conditions.

CONCAVE



CONCAVE is a term applied to a weld when the top layer finishes below the plane of the surrounding material as at Fig. "G" above, or beneath a plane of 45 degrees at an angular connection as at Figs. "H" and "J" above.

To be used as a weld of no further importance than filling in a seam or opening, or for strictly caulking purposes, when it is found that a minimum amount of welding material will suffice to sustain a specified pound square inch pressure without leakage. In this "type of weld" it will not be necessary for the designer ordinarily to specify the number of layers of material, owing to the lack of structural importance.



FLUSH is a term applied to a weld when the top layer is finished perfectly flat or on the same plane as on the adjoining material as shown at Figs. "D" and "E" above, or at an angle of 45 degrees when used to connect two surfaces at an angle to each other as at Fig. "F" above. This type of weld is to be used where a maximum tensile strength is not all important and must be specified by the designer, together with a minimum number of layers of welding material.

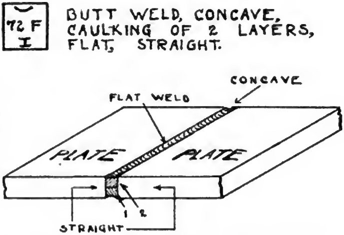
tions, namely, flat, horizontal, vertical and overhead. The flat is the most usual and probably the most favorable position, as tho it were being done on a table. The horizontal is such a seam as would be made on a wall along the top of the wainscoting. The vertical, of course, is obvious, as is also the overhead. As to the speed of welding, there is not much difference between the flat and the vertical, and when the welders become skilled there is not much choice, because they can make the two with equal rapidity. When the horizontal weld is considered, it would probably go only 90 per cent. as fast as on the flat weld. The quality of the welds is probably about equal. On the overhead weld the speed falls, being only about 60 per cent. that of the flat weld. It is slow because it is difficult to make the arc work uphill, and the strain on the operator is greater. The strength of the welds made in different positions is up to the welder and there can be no rule set. Some experts, however, say that if the flat is 100 per cent., the vertical is 90 per cent., the horizontal 85 per cent. and the overhead 80 per cent., but that is based on the margin of safety rather than the actual fact, and the research committee, at least, is not yet to the point of stating that any difference in the quality of the weld is due to its position.

KIND OF WELD

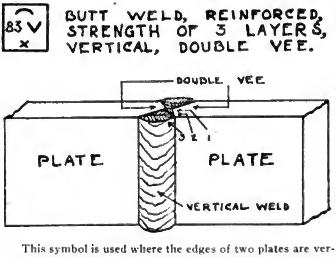
The next thing the designer has to tell the welder is the kind of weld to make. The Tack weld shown in Fig. 6 is represented by the symbol 6, and is used where neither strength nor tightness is needed. In specifying a tack weld it is necessary to give the length of each tack and the distance from centre to centre, so that the man on the job may know what the designer contemplated in the way of strength. The next is a caulking weld, symbol 7, in which the prime requisite is not strength, but requisite density to assure water or oil tightness. I have great respect for the man who drew these figures, because on paper there is very little difference in them. Symbol 8 is a strength weld, and, as a matter of fact, a good strength weld will be also usually a good caulking weld. For completion, however, there is specified a composite weld, which has for its symbol the figure 9. This weld has both qualities of the strength and caulking welds. It embodies the strength of the former and the density of the latter.

TYPE OF WELD

The next subdivision is here called the "type of weld," but that name may be changed, for the sake of simplifying the terminology. The suggestion, at least, has been made to change it to "finish of weld" (see Fig. 7). The first "type of weld" is the Reinforced Weld, as is very clearly shown in Fig. 7 in three different types. In the flush type the metal is finished straight across, as in the case of a flush rivet. The Concave weld shows the surface does not need to be filled up full, as in the case of these three illustrations. Being so closely related to strength, the finish of the weld will

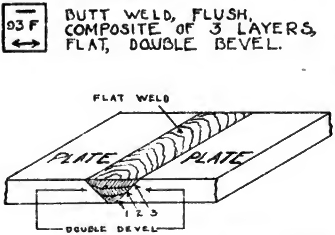


The symbol shown represents a Butt Weld between two plates with the welding material finished concaved and applied in a minimum of two layers to take the place of caulking. The edges of the plates are left in a natural shear cut finish. This symbol will be quite frequently used for deck plating or any other place where strength is not essential, but where the material must be water, air or oil tight.



This symbol is used where the edges of two plates are vertically butted together and welded as a strength member. The edges of the adjoining plates are finished with a "Double Vee" and the minimum of three layers of welding material applied from each side, finished with a convex surface, thereby making the sectional area per square inch of the weld greater than that of the plates. This will be a conventional symbol for shell plating or any other members requiring a maximum tensile strength, where the welding can be done from both sides of the work.

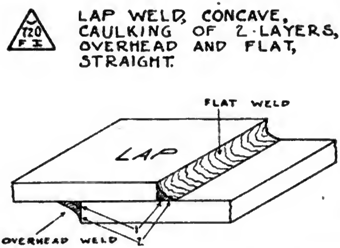
ultimately have to be specified by the drafting room. To-day the designer asks the welder how to best do a job, but of course, ultimately, the design properly symbolized will be shown on the drawing or else will be covered by standard specifications.



BUTT WELD, FLUSH, COMPOSITE OF 3 LAYERS, FLAT, DOUBLE BEVEL.

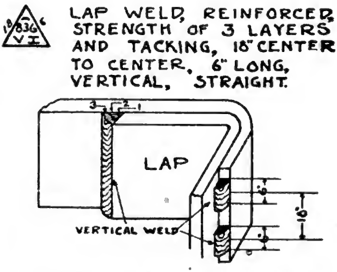
This symbol shows two plates butted together in a flat position where the welding can only be applied from the top surface. It shows a weld required for plating where both strength and water-tightness are to be considered. The welding material is applied in a minimum of three layers and finished flush with the level of the plates. Both edges of the adjoining plates are beveled to an angle, the degrees of which are left to the discretion and judgment of the designer, and should only be used when it is impossible to weld from both sides of the work.

Fig. 8 shows the combination of symbols. The square is the symbol of the Butt joint. The inverted half moon inside the square at the top shows that it is a concave type of weld. Underneath this the first numeral "7" shows that it is a caulking weld, the next numeral "2" behind the "7" shows that the operator must put in two layers. The letter "F" on the same line shows that the position of the weld is flat and the "I" in the bottom of the square indicates that the design of the weld is straight. In the next diagram (Fig. 8) the symbols



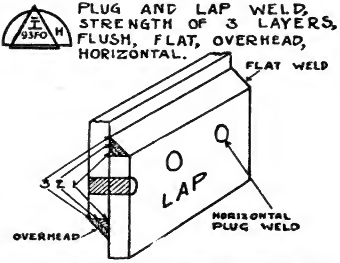
LAP WELD, CONCAVE, CAULKING OF 2-LAYERS, OVERHEAD AND FLAT, STRAIGHT.

The sketch shows the edges of two plates lapping each other with the welding material applied in not less than two layers at each edge, with a concaved caulking finish, so applied as to make the welded seams absolutely water, air or oil tight. The edges of the plates themselves are left in a natural or sheared finish. Conditions of this kind will often occur around bulkhead door frames where maximum strength is not absolutely essential.



LAP WELD, REINFORCED, STRENGTH OF 3 LAYERS AND TACKING, 18" CENTER TO CENTER, 6" LONG, VERTICAL, STRAIGHT.

The illustration herein shown is somewhat exaggerated as regards the bending of the plates, but it is only shown this way to fully illustrate the tack and continuous weld. It shows the edges of the plates lapped with one edge welded with a continuous weld of a minimum of three layers with a reinforced finish, thereby giving a maximum tensile strength to the weld, and the other edge of the plate, tack welded. The tacks are six inches long with a space of 12 inches between the welds or 18 inches from centre to centre of welds. In both cases, the edges of plates are left in a natural or sheared state.



PLUG AND LAP WELD, STRENGTH OF 3 LAYERS, FLUSH, FLAT, OVERHEAD, HORIZONTAL.

The sketch shows a condition exaggerated, which is apt to occur in side plating where the plates were held in position with bolts for the purpose of alignment before being welded. The edges are to be welded with a minimum of three layers of welding material for a strength weld and finished flush, and after the bolts are removed, the holes thus left are to be filled in with welding material in a manner prescribed for strength welding. The edges of the plates are to be left in a natural or sheared state, which is customary in most cases of lapped welding.

may be read off in the same way as above illustrated. In the third diagram on Fig. 8 the square symbol indicates the butt weld, the dash in the top of the square shows that it is flush, the numeral "9" shows that it is composite, numeral "3" determines the number of layers, the letter "F" makes it a flat weld and at the bottom the dash with the arrow heads on each end designates it as a double bevel design.

Fig. 9 illustrates some additional symbols showing a Caulking weld of two layers. It is shown both overhead and flat and the plate finish is straight. The second diagram in Fig. 9 is more complicated, and is of a lap weld, reinforced with three layers after tacking. The distance of the tacking from centre to centre and length of the tacks and the finish are all given. The third diagram in Fig. 9 is another application of the same thing, in which two kinds of joints appear, the symbols being superimposed, indicating that it is a plug and lap joint. Many combinations of symbols have been worked out and are very interesting, as is also the ease with which they may be placed on the drawing.

DESIGN OF BATTLE-TOWING TARGET

Fig. 10 shows a portion of the steel keel for a battle-towing target now building at the Norfolk Navy Yard. This design was prepared for me by the subcommittee of Design of the Electric Welding Committee, and shows the method of building the steel keel with electrically welded joints. It also demonstrates the ease of applying the symbols which I have just explained, and I wish to call attention to the lack of the usual dimensioning that would be necessary on a similar riveted structure. The upper structure is of wood. The buoyancy is all in the wood so that if the target is shot to pieces the structure will still float. The wood is fitted to the shelf and built up to quite a height. The keel goes down some 15 feet and is about a foot and a half wide. The sides are of 15-pound plates and the floors are set up between the two sides. This keel is full of water and pig-iron so as to hold the target vertically. This structure is rigid and subject to all the wave stresses that are met at sea. While it is not a ship, it is, nevertheless, subjected to the same stresses and sea conditions that would affect any seagoing vessel, and we hope by introducing a variety of welds in this job to get a good line on the possibilities of electric welding.

GENERAL NOTES

All butt straps to be of 15 # plating 3" wide and to be applied on inboard side of plating. All butt straps to be fastened to the forward plate in the shops. All symbols bearing a small ● represent shop work.

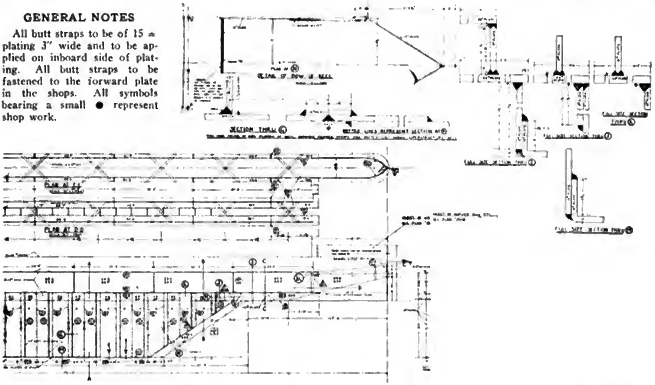


Fig. 11 gives a number of details of the welded joints and again emphasizes the ease and rapidity with which drawings for welded construction can be made. There will no doubt be a great deal of saving in the drafting room as well as in the shop when this application is generally applied to shipbuilding processes.

This practically finishes the question of nomenclature. It is not so complicated after all in its conception, and I do not think it will be found very complicated in practice. Its use is absolutely necessary, if we are going to understand each other as we must.

I consider, however, that the main message that I can deliver to the shipbuilder is—For goodness' sake, go ahead and use arc welding. We do not want arc welding of the whole ship yet, nor do we want to do extensive jobs, but there are thousands of jobs that can be done profitably, in money and time, by the help of arc welding, and by the help of the classification societies, which have already done so much in opening up the extensive field of this very remarkable addition to the industry of shipbuilding.

Second Discussion

"TOOLS FOR ELECTRIC WELDING"*

By W. L. MERRILL

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Schenectady, N. Y.

BEFORE discussing the tools and the methods of producing welds, it may be well briefly to go into some of the fundamental principles of the processes of arc and spot welding, since, at the present time, these types of welds are the most important so far as making progress in the shipbuilding program.

ARC WELDING

In a sense arc welding is different from blacksmith welding, or spot welding, or welding where no additional metals are used for filling purposes, and is well illustrated in the principle on which the electric furnace is operated. In Fig. 1 is shown a very general type of such a furnace, having, let us say, two electrodes. Here we have the furnace charge consisting of scrap iron, pig iron, iron ore or other metals; the source of electric supply; and the regulators for maintaining a definite current.

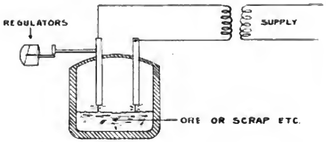

FIG. 1

There are many types of these furnaces in use, but, regardless of the type, there is but one object to be accomplished, *i.e.*, to put heat in the charge, bring it to temperature, refine it, and make it into a molten state to produce castings. The accomplishment of this object in the electric furnace is brought about by the application of the same principles and instruments used in arc welding, with the difference that in the furnace carbon is used to conduct the current down to the metal, whereas in arc welding a metal electrode is employed, the end of which melts as the heat becomes intense enough to fuse the metal.

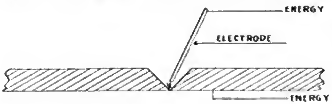

FIG. 2

For illustration, let us consider a most simple kind of weld; say two pieces of steel plate (see Fig. 2) which are to be joined together. In this case the plate becomes one side of the welded surface, while the material added to fill the gap between the plates forms the other side. As the arc is started and heat produced, the sole object is to create a miniature arc furnace, supplying the material by hand in the same way as the regulator on the furnace runs the electrode down and maintains a definite length of arc. If the currents are not properly adjusted; if the apparatus is not arranged so as to give the proper welding conditions, or the operator unskilled, a weld will be produced in most cases like the one shown in Fig. 3. There will be no difficulty in filling up the groove with molten metal, but a section cut thru the weld will, in most cases, show a cleavage, even to leaving the original tool marks visible. Altho this is not a weld, there is some adhesion and more or less strength. To weld properly, however, the operator must start at the bottom of the groove, and, by alternately filling in and then melting a little metal at a time, continue in this manner until the gap has been entirely filled as shown in Fig. 4.

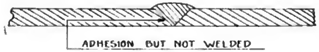

FIG. 3

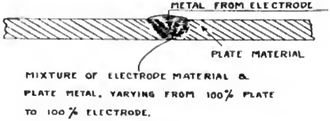
METAL FROM ELECTRODE
PLATE MATERIAL
MIXTURE OF ELECTRODE MATERIAL & PLATE METAL, VARYING FROM 100% PLATE TO 100% ELECTRODE.

FIG. 4

ARC WELDING TOOLS

Understanding, then, the conditions for which we are striving, and bearing in mind that there are really only three tools for arc welding, let us see what we have to start with. Of these tools, first in order is the source of current; second, some transforming or control device to control the current within necessary limitations; and third, the skill and brain of the operator. In estimating roughly the worth of these tools, I would valuate the current and controlling device at 10 per cent., and the skill and brain of the operator at 90 per cent., and accordingly I consider a most important factor in this industry the coöperation schools, since in these schools welders will be trained who can do entirely satisfactory work with the tools supplied them.

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* This is the second of a series of lectures on "Electric Welding" held under the auspices of the U. S. Shipping Board in the Auditorium of the Engineers' Club of Philadelphia, Wednesday, July 10, 1918.

CHOICE OF CURRENT

Successful welding can be done with both alternating and direct current, and both systems have their advantages. In general, however, local conditions, such as the kind of current with which the shipyard is supplied, together with location of the welding operations, *i.e.*, whether done in the shop or field, may well be the determining factors.

In the case of shop welding, where the operators are close together, the work is brought to the welding apparatus rather than the apparatus to the work. It would seem to be folly to transform from D.C. to A.C., or *vice versa*, but there are limitations which must be considered. If a considerable number of welders are to be employed, welding directly by A.C., the low power factor of the load must be taken into consideration with the supply system; and while it would be folly to transform from D.C. to A.C., it might be necessary to transform from A.C. to D.C. for any considerable number of welders. In such a case, only by a study of the conditions prevailing, and the ability of either A.C. or D.C. equipment to meet these conditions, can the choice of current be determined.

DISTRIBUTION SYSTEMS

If we bear in mind that a very low voltage is used in carrying on any welding operation—a voltage ranging from 12 to 15 volts, using direct current, and perhaps 20 to 30 volts using alternating current—it will be realized that the matter of distribution over a ship becomes a problem.

If a central station be placed near the ship to transmit the current at these low voltages to the required points, it will mean that the cable supply will be in the way, and present probably even a more serious fault than does air hose at the present time. From an engineering standpoint, also, it would be unpracticable to distribute at these low voltages, so that it is necessary to arrange some device by which it is possible to divide the power into different sections.

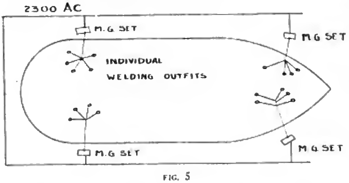


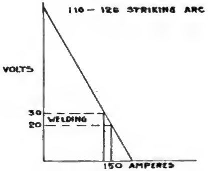
FIG. 5

One system that has been worked out and will probably be installed in one of the larger yards, where a voltage of 2200 is used to start with, is shown in Fig. 5. Here four 60-cycle motor-generator sets, each having a potential of 60 volts and a resistance to reduce that voltage wherever the men happen to be working, are employed. Each motor-generator set has a capacity equal to one-fourth that required by the total number of welders, which in this case is about 60, and therefore distributes 15 operators over each section.

Another system that can be used requires, from the nature of the system, 125 volts direct current to start with, so that in case the yard were supplied as above with 2200 volts A.C. it would be necessary to transform from 2200 to 125, each welder down in the ship having his own motor-generator set.

Still another system which can be used—and is being used, by the way, in some yards—consists of leading up to some convenient deck on the ship with 2200 volts and there reducing down thru a static transformer, to, say, 440 volts A.C., instead of reducing to 125 volts D.C. In this case motor-generator sets for each welder reducing from 440 volts A.C. to 40 or 60 volts D.C. would be used.

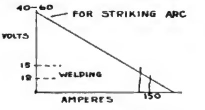
A still further system consists of a reduction to 110 to 125 volts A.C., then running with dead resistance or reactance, and welding directly with A.C.



A.C. RESISTANCE OR REACTANCE

FIG. 6

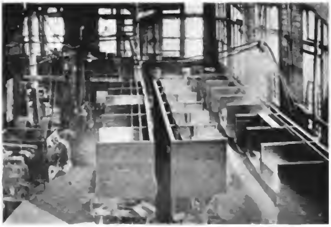
Due to some peculiarity in striking the arc, it becomes necessary to start with 110 volts, or a little over, in the case of A.C., while with direct current, 40 to 60 volts are all that are necessary. Therefore, assuming that the current required in either A.C. or D.C. welding is the same, we see that a basis may be had for computing, in each case, the capacity of the lines. See Figs. 6 and 7.



DC CONSTANT POTENTIAL

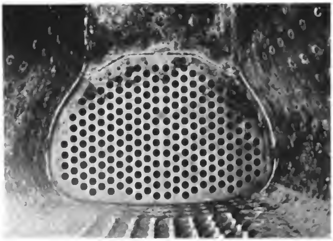
40 OR 60 VOLTS, RESISTANCE REGULATION

FIG. 7

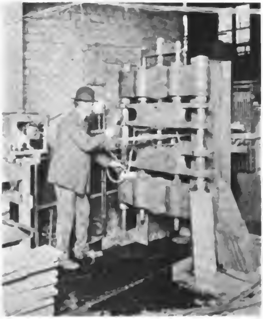


School for Electric Arc Welders established by the Emergency Fleet Corporation at the plant of the General Electric Company.

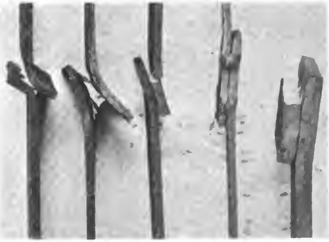
Front view welding booth. G. E. Welding School.



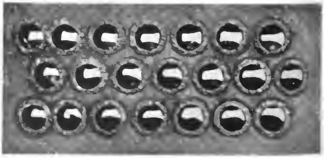
Interior of locomotive fire box. Back tube sheet ready for welding by arc process.



Machine for experimental welding of heavy steel by electricity current. Capacity, 100,000 amperes. Pressure capacity, 36 tons. Sample weld being made.



Electrically welded steel plates ½ inch and 1 inch thick after being tested in tension. Showing effect of compound stresses due to effect in line of tension caused by the lapping of the pales.



Two-inch tubes electric arc welded in ¼-in. boiler plate, showing welds and battered tubes. No oil leaks produced.

HOLDERS, MASKS

Of the other tools, such as electrode holders, and masks for the protection of the operators, very little need be said. There are many of these devices in use, each of which is doing good work in the railroad shops and other places where electric welding has been used for a number of years. It is hoped that some of the best ones will be chosen and standardized for ship work.

SPOT WELDING

So far as electric welding is concerned, spot welding is one of the oldest arts. It has been used for many years in the welding of thin plates up to a thickness of one-quarter inch, and recent experiments have shown it feasible to spot weld in one operation as many as three one-inch plates.[1]

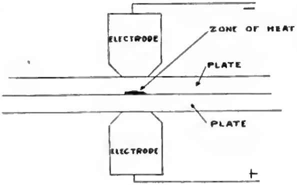


FIG. 8

The action which takes place in the spot weld is practically the same as that which takes place when a blacksmith makes a weld. The plates are put under a heavy hydraulic or air pressure, and an alternating current at high density sent thru the plates by means of electrodes located immediately above and below the area under compression. See Fig. 9. As the current heats up the contact area of the plates (see Fig. 8), this area becomes plastic and the pressure squeezes the surfaces together. While in that condition they cool. First the current is taken off, then the pressure and the weld is complete.

SPOT-WELDING TOOLS

So far as shipbuilding is concerned, the extent to which spot welding may be commercially applied has not yet been determined. Three experimental machines are, however, being built at the present time for the Hog Island yard by means of which it is hoped the limitations of spot welding in this field may be ascertained.

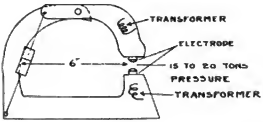


FIG. 9

Fig. 9 shows one of these machines, a heavy welder, with a capacity of 15 to 20 tons pressure, which will have about a six-foot gap. With this machine we expect to fabricate by spot welding, with no previous work except the cutting, such portable structures as deck houses, which are now being put together in the shops by riveting.

The second machine (see Fig. 10), which is being built on exactly the same principle, but for another purpose, is to be used in making up the floors. With this machine it is hoped that, when the plates and angles have to be assembled, it will be possible to go around them and "spot" them together in the same way as is now done with a bull riveter. While it is not thought possible to fabricate this work as quickly by spot welding as by riveting, it is nevertheless expected to show a saving in the total time required when all the work preliminary to riveting is taken into consideration. Even marking with a punch may be eliminated, where numbers of pieces of the same size and dimensions are welded, if, as is expected, a method of clamping may be worked out.

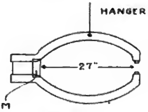


FIG. 10

The third experimental machine, now being built, is exactly like the second, and of the same capacity but of a smaller size. This machine will be used for smaller work where the throat of the other machine is not necessary, and it is expected that there will be a large field for its use in putting on fishplates, angles and other structural shapes.

From these machines it is expected to obtain data showing comparisons in labor, cost and time between riveting and spot welding. If, as confidently expected, these comparisons are favorable to spot welding, it will mean that the material can go directly from the shears to the welders without any previous punching either in the fabrication shops or in the shipyard.

The remaining discussions will appear in future issues of the Journal.

THE RELATION OF LIGHT TO HEALTH*

By CHARLES E. de M. SAJOUS, M.D., LL.D., Sc.D.

A discussion of the possibilities in the Illuminating Engineer's field for the development of the applications of light for the preservation of health and the cure of disease.

ALTHO the influence of light upon health has received considerable attention in recent years, a perusal of the literature of the subject indicates that the fundamental principle of the question, the manner in which our tissues are actually affected by radiant energy has remained obscure. It is known, for instance, that light favors tissue oxidation and the perpetual whirlpool in the cells of all tissues which constitute the life of the cell; we know that it favors the formation of blood-cells and their active agent, hemoglobin, thru which the oxygen of the air, taken up in the lungs, is transported to the tissues; we know that the lymphatic system, that great filtering plant of the blood-serum, becomes, at least in the superficial tissues, especially active in its work of purification; we know that it favors the eliminatory functions of the skin; we know that by exciting the multitude of minute cutaneous nerve organs, it conveys to the spinal cord and brain impulses which, by exciting therein various nerve centers, cause them to send out stimulating impulses to the sweat-glands, the heart, the blood-vessels and other organs, thus increasing, so to say, the vigor of their functions. Yet, if we ask the simple question *how* are these many beneficial effects produced, but little information is vouchsafed. Briefly, we are left virtually in the dark.

What I wish to submit is a new line of thought based on many solidly grounded facts, which tend to show the manner in which radiant energy brings about its beneficial effects. It is based on work that has already contributed much to our knowledge of biological phenomena, and which bids fair to revolutionize scientific medicine by filling gaps and eliminating complexities; and this, even tho it has entailed the addition of at least six organs to the many which already render our investigational labors so arduous. Yet these six newly identified organs—new continents for explorers, I might say—have this in common: They are all closely connected with, and serve to perpetuate, those functions that sustain both the life of our tissues and their protection against disease. They may be said to penetrate, in fact, into the very sanctum of our physical existence on earth. Now, it happens that light, or rather radiant energy, effectively influences some of the most active of these organs, whose wonderful functions have been actively studied since that great Franco-American, Brown-Sequard, first emphasized their importance. He described them as the "organs of internal secretion," because their products or secretions, unlike those of salivary or sweat-glands, for instance, which secrete externally, are dealt out internally, that is to say, in the blood-stream or kindred fluids. I must, however, introduce a word of caution, in the present connection, for the lines of thought introduced this evening are but my own, and, altho based on solid data, are only submitted as working propositions, or as a field for new explorations.

It is perhaps unnecessary to recall that our tissues are made up of closely crowded cells, composed in turn of living substance known as protoplasm. This applies to all living matter, vegetal as well as animal. While we know that protoplasm is composed of many chemical elements, arranged in a complex manner, we obtain therefrom no hint of the marvelous property we term "life"—even tho it is to this special phase of the problem that I will refer to-night. While protoplasm cells differ in appearance and structure in different plants and animals, tho very similar in chemical attributes, they all contain a nucleus or kernel which has much to do with their vital activities. They have also in common two properties, those of movement and contractility.

How is this living protoplasm affected by light? A beam of light will cause a minute mass of protoplasm to expand or retract; if, however, the intensity of the light exceeds a certain limit, the contraction will become relatively intense and sharp. This is an expression of the inherent irritability just referred to. It is sufficiently marked in some of the smaller organisms to awaken continuous motion or even active propulsion, motion ceasing at once as soon as the light is removed. Briefly, light means active life in these organisms and darkness but a potential stage of vital activity. They seek the brighter areas of the fluid in which they are immersed, an illumined area becoming a meeting spot, as it were, of their kind. Their growth is greatly influenced as well as their shape. Even the higher organisms show this influence, certain organs, those of fructification in mycelia, for instance, failing totally to develop in darkness.

So marked is the influence of light upon vital activities that it has been taken advantage of to promote the growth of plants. Thus in Siemen's experiments plants exposed during the day to normal conditions in the greenhouse and to six hours of electric light at night were found to surpass greatly in their vigor and color similar plants grown under normal conditions in the greenhouse. While a powerful light used bare, gave poor results in the cultivation of fruit, owing to the ultra-violet rays entailed, a clear glass globe placed over the lamp greatly favored their development without in the least impairing their flavor. "Peas, raspberries, strawberries, grapes, melons and bananas fruited early and abundantly under continuous light, solar light by day and electric light by night. . . . Wheat, barley and oats grew so rapidly that they fell to the ground of their own weight." Might these few of the many experiments recorded not be taken advantage of during the present strain for wheat and other vegetable staples where water power would supply an inexhaustible and inexpensive source of energy? Plants grown under such conditions are not only produced with far greater rapidity, but they are also more robust and richer in nutritious materials.

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* Presented before the Philadelphia Section of the Illuminating Engineering Society, at the Engineers' Club, May 17, 1918.

Approaching nearer the higher organisms as regards the influence of light upon them, we must bear in mind the often overlooked fact that respiration, that is to say the absorption of oxygen and the elimination of carbon dioxide, continues equally well, even in plants, in light and darkness, while the chlorophyll function fails, the plant remaining pale where light is not supplied. While this pallor is due to the loss of oxygen by the chlorophyll, the fact remains that we are dealing with a function which is quite the converse of the former. Briefly, the plant breathes as we breathe, taking up oxygen and giving off carbonic acid, but it also does the reverse: its chlorophyll or coloring matter gives off oxygen and takes up carbonic acid and breaks it up, setting the oxygen free; but in doing this, it liberates the carbon to build up sugar, gum, starch, albumin and cellulose, all essential materials in structure and development of the plant.

This influence of light on plants is but the counterpart of its action upon our tissues. It is here that we must recall the close chemical structure of animal and vegetable proteids, *i.e.*, the similarity between vegetal and animal protoplasm. This applies not only to the carbon, hydrogen, nitrogen, oxygen and sulphur percentages, but also to their properties and reactions. Briefly, the living matter of our tissues and that of plants is on the whole the same.

The effects of light on plant protoplasm are usually attributed to an excito-motor action, due mainly to the blue or indigo, violet or ultra-violet rays of light. In the human organism this same excito-motor effect may also be discerned in various ways. While impinging upon the whole of the exposed skin, the light excites mainly the sensory nerve organs which endow it and also the mucous membranes with the sense of touch, the sensations of heat, cold, pain, etc. Excited, these superficial sense organs convey impulses to the deeper nerve centers, the brain or spinal cord, and these send back outward impulses not only to the skin, its sweat-glands, etc., but also the centers governing other functions. An example of this is afforded by the hypersensitive centers of the unfortunate hay fever sufferer. Many find all their symptoms greatly aggravated when they are exposed to bright light, and most of them are obliged to wear dark glasses. Sneezing, which brings into play a large number of muscles, lachrymation and the whole gamut of symptoms of the disease, may be awakened merely because the bright light of day, by impinging upon their retina, transmits to the deeper centers vibratory energy which excites these hypersensitive centers to excessive activity and manifests itself as an excito-motor phenomenon as complex as it is unpleasant.

What is the nature of the phenomenon? We have seen that the absence of light does not influence the respiratory function of the plant, but that its chlorophyll assimilation, its fundamental function, so to say, ceases in the absence of light energy. Yet, just as the respiratory process involves the participation of oxygen, so does it seem probable that oxygen must be regarded as factor of the action of light upon chlorophyll assimilation. This might appear to you as far afield of the subject in point, the influence of light on health, but as you will see presently, such is not the case. Indeed, personal investigations appear to me to have shown that there exists at least a close kinship between this important function of plants and one which in man has failed so far to be recognized. Briefly, from my viewpoint, just as we have seen that the chemical structure of animal and plant protoplasm are practically identical, so is there in the animal tissues a chlorophyll-like substance which endows them, precisely as it does the plant in full activity, with their vital energy.

The importance of this fact to lighting engineers is that it will tend to confirm, and perhaps explain, the close kinship between the chemistry of life and the light of day. Indeed, we have seen that growth and development of plants are promoted by light. We have, therefore, both life and growth, and I shall show later, the preservation of health, and even the cure of disease in some instances, as goals for your efforts.

What then is the substance—the *Deus ex machina*—of chlorophyll, and also from my viewpoint, of the vital activities? What evidence has been garnered so far, from the laboratory, imposes the statement, borrowed from Newton, that "it would appear as if" we were dealing with a ferment common to living things, and the far-reaching powers of which are only beginning to be appreciated. "We find it impossible," wrote Herbert Spencer in his Synthetic Philosophy, "to think of life as imported into the unit of protoplasm from without; and yet we find it impossible to conceive of it emerging from the co-operation of the components." He, therefore, urged the need of what he termed a "dynamic element of life," a working substance, as it were, to account for the vital process in the tissues proper.

That ferments play an active rôle in the activities of tissue cells and fluids has long been held by many investigators, but their mode of action has remained obscure. Their typical reactions are, however, clearly discernible in all living tissues, vegetal or animal. Certain of them, known as "oxidases," tend, as their name indicates, to promote oxidation. These oxidases have been divided into several groups, each of which presents more or less specific properties. On the whole, however, they all seem to be able, as it were, to *handle* the oxygen that is present in the surrounding medium, the air especially, and to crowd it on, so to say, the substance they affect

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without becoming destroyed themselves, a process known as "catalysis." Now, the respiratory and nutritional activities of plants are deeply influenced by these oxidases as shown by various tests; and a substance possessing these same or similar properties, exists, as shown by a comprehensive series of physiological and chemical facts, in our cells and body fluids. This oxidizing ferment seems able to carry on, if any ferment is capable of doing so, the functions that Herbert Spencer attributes to the "dynamic element of life."

Moreover, the personal labors referred to apparently showed—I say "apparently" because the confirmation of such comprehensive deductions requires not years but decades of labor by many independent investigators—that the secretion of two small organs located on top of the kidneys contained this dynamic element; that as a constituent of this secretion it was carried in the blood—duly found to contain it—to the heart and lungs; and once in the latter and to the walls of the air cells. Here it becomes loaded with the oxygen of the air; and finally, having entered the red corpuscles as a constituent of their known oxidizing substance, hemoglobin, reaches all tissue cells, *i.e.*, every living cell of the body, to sustain therein, as far as oxygen can do it, all its vital activities.

As every physician now knows, the power of the secretion of the adrenals is simply amazing. A quantity of its active principle hardly appreciable to the naked eye, one eight-hundredth of a grain, will affect the entire body. It is capable of resuscitating animals, when used in proper solution, fifteen minutes after all signs of life have ceased; it has been found to keep *decapitated* animals alive over nine hours. Indeed, it is commonly used in practice to-day to keep sufferers away from the threshold of death, when debilitating diseases have reduced the dynamic activities of the tissue cells to their lowest ebb. I feel confident that when the powers of the adrenal secretion will have been duly appreciated, they will prove a blessing to the world of suffering and prolong life in a proportion of cases now lost.

How, again, can all this be of professional interest to the lighting engineer? It is here that the connection will become apparent.

As plants prepare for the winter's rest, they divest themselves of their beautiful vestments; the fall is on. They seem, however, to crave admiration even then, and the changes of color their leaves undergo have often inspired the bard. And yet, under the unpoetic analysis of the laboratory, the beautiful coloring is but a sign of progressive decay. In view of what I have said, in fact, we have proof of this for—and this is the link between plant and animal life on the one hand and the influence of light on the other—the "dynamic element of life," which I have tentatively identified as the adrenal principle, looms up as a feature of the play of colors the foliage undergoes before its fall. Indeed, if in the laboratory we watch a solution of adrenal extract undergo deterioration exposed to the air and light, many of the shades, particularly those of the yellowish-brown and bronze, imitate not only the autumn leaves, but also the shades of pigmentation witnessed on the human skin, hair and mucous membranes known as melanins. In certain diseases, Addison's disease for example, the cutaneous bronzing is identical with that of many autumn leaves. There is, moreover, good reason for the belief that the yellow skin of jaundice is due to a pigment akin to that observed in the yellow leaves in process of deterioration and which we may trace thru various tests thruout virtually the whole living world, vegetal and animal.

All these varigated hues, influenced more or less by the presence of elements, manganese, iron, etc., common to the structures observed, are the embers, so to say, of an active process which constitutes their living state. The chlorophyll which endows the living leaf with its green color is a type of the pigment a prototype of which is the melanin of our own tissues. As does the latter, it embodies a ferment, catalase, which in keeping with our adrenal ferment, acts as its dynamic agent, the initiator and perpetuator of the living state. Altho the end to be attained is different, the chlorophyll function differing from the metabolic function of our tissues, the fact remains that in both, the activating factor is a ferment—the "dynamic element of life." And just as it is the catalase ferment that light activates in the chlorophyll function, so is what I have termed "adrenoxidase," the adrenal oxidizing ferment, activated by light, that is to say, radiant energy.

The catalytic influence of light in the same connection has long been suspected. It was studied by Ostwald and Neuberg and also by Berthelot many years ago, but without much result as to living tissues. This is because they credited radiant energy itself with catalytic properties, whereas, from my viewpoint, these belong to the oxidizing ferment. Thus, violet and ultra-violet rays are known to activate the oxidation of methylene blue; but this is because the tissue fluids of the animal or vegetable tested contain an oxidizing ferment or oxidase.

On the whole, we may summarize this newer conception submitted in respect to the influence of light upon tissue life, by the statement that it activates the functional efficiency of the ferment which sustains life and, therefore, promotes the maintenance of health.

In doing this, however, it also activates the defensive functions of the body and thus protects it against disease.

Indeed, so true is this that I will now refer briefly to the curative efficiency of solar energy, also thru the intermediary of ferment action.

The word "ferment" is steadily being replaced in medical phraseology by the word "enzyme" for reasons which I need not mention here. In the words of Professor Mendel, of Yale, "Enzymes are no longer thought of exclusively as agents of the digestive apparatus; they enter everywhere into the manifold activities of cells in almost every feature of metabolism." In other words, the same ferments, pepsin, trypsin and others which first

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prepare foodstuff in the stomach and intestine, for assimilation by the tissues of the body at large, are the same agents which carry on certain functions in the intimacy of the tissues.

Considerable evidence is available to show that these digestive ferments are carried from the alimentary canal to the tissue cells by certain white corpuscles of the blood, in which they are readily found. To these white corpuscles belong the phagocytes, which ingest and digest disease germs. We thus have digestive ferments taking part—along, let me add, with the oxidizing ferment previously referred to as the "dynamic element of life"—not only in the vital processes of each tissue cells, but also the defense of the body against disease.

There is no doubt about this. Professor Vaughan, of the University of Michigan, for instance, states that "the cell which can no longer supply a digestive ferment is already dead." Another distinguished biochemist, Abderhalden, writes: "Each separate cell, with very few exceptions, disposes of the same or similar ferments as those secreted by the digestive glands in the intestinal canal" and refers to them as "defensive ferments."

We shall presently see that it affords the clue to the manner in which radiant energy, that is to say sunlight and electricity, not only tend to preserve health, but to contribute to its defence when compromised.

Prevost's theory of mobile temperature equilibrium is now known to apply to radiant heat as well as to heat energy derived from other sources. It is simply that if two bodies of different temperatures are placed close to each other, the warmer of the two will lose heat by emitting radiant heat which the colder body will take up until the temperature of both is equalized. Briefly, the skin absorbs radiant heat when the cutaneous temperature is lower than that of the radiations received, up to certain limits (influenced by the perspiration and other factors) and the temperature of the tissues of, and beneath, the skin is thus raised.

The penetration of radiant light thru the tissues when long wave lengths characterize the rays is considerable, that of red rays, for instance, exceeding one inch. Careful experiments by Rollier showed that solar rays could penetrate the hand and forearm, and also, under favorable circumstances, the entire chest.

How does light energy influence the vital process of those tissues and contribute to the defense of the body against disease?

Charcot, the French neurologist, as far back as 1859, urged that we should distinguish between the purely chemical effects and those produced by heat. In the present connection we probably are dealing with a process in which the chemico-physical effects credited to oxidizing ferment previously described and heat both take part, particularly near the surface.

There exists immediately under the superficial tissue a great system of small interwoven canals which, so to say, act as sewers of the tissue cells. They serve not only to carry off, but also to purify the fluids received from those cells by breaking down, as far as possible, the wastes and detritus that they form while carrying on the process which constitutes their life. These channels are interspersed with glands that contain phagocytes, *i.e.*, cells of the type that destroy, by means of their digestive ferments, disease germs and other harmful substances that the small canals carry to them from every direction. This system of lymph channels and glands, known as the lymphatic system, is a prominent weapon of defense. Everyone has seen lymph, a whitish, viscid fluid, collect on abrasions, and also enlarged glands on the neck of children. These latter are enlarged lymphatic glands trying to destroy bacteria from some source, the tonsils, adenoids, etc., thus preventing general infection.

The beneficial influence of sunlight is readily accounted for when we take the lymphatic system into consideration in addition to the tissue cells, in view of the effect of light energy as manifested by its radiated heat. Indeed,—and this is the dominating factor in the process—the ferments of both kinds previously referred to, those which promote tissue oxidation and those that digest and destroy bacteria and organic poisons, become increasingly active as the heat to which they are exposed is increased, and we obtain as result an increase of both vital activity and defensive aggressiveness.

This *increased efficiency of ferments under the influence of increased temperature* is the method adopted by Nature, according to my own viewpoint. It explains the process we term "fever," long deemed an enemy, but in reality a defensive function calculated to destroy poisonous substances or germs that have found their way into the body fluids and cells from a focus somewhere, either in the superficial or deep tissues. In the course of fever, the germ destroyers, or phagocytes, are not alone at work in the blood-stream, but the whole internal lining of the blood-vessels themselves is made up of these germ-destroying cells. Again, the lymphatic vessels which act as drains for the tissue cells, we have seen, afford additional aid in the defensive process by means of the multitudes of phagocyte-laden glands thru which the serum obtained from the blood by the tissue cells must pass before it is returned to the circulation.

On the whole, the relation of light to health may be summarized, in view of the few data submitted, by the statement that it is intimately bound up with the perpetuation of life, whether the tissues be normal or diseased. It tends to sustain health by promoting, as radiant energy, the activity of the oxidizing ferment adrenozidase, which sustains the oxidation of tissue cells, an essential function of their life. It tends to defend the cells, when endangered by certain germs and poisons, by enhancing thru the heat energy developed the efficiency of the defensive ferments which submit these harmful agencies to digestive destruction.

The Motor Truck Is Essential

THE continued manufacture of motor trucks, to be used in the transportation of materials for direct or indirect war work or to be used in work of national civilian importance, has been declared an essential.

While motor trucks are of great importance in relieving transportation problems, their manufacture cannot be out of proportion to other transportation necessities, such as railroads and steamships. A grave responsibility has been placed not only upon the manufacturer of motor trucks, but upon the present owners of such vehicles. We must all do our part to the limit of our ability. The situation is this:

FIRST, motor trucks are to be sold *only* for necessary work, either directly for war work or to facilitate the transportation of such essentials as food, fuel, etc., or for important construction work.

SECOND, motor truck owners must see to it that their trucks are operated so as to require the minimum of spare parts and repair work.

THIRD, no truck must be discarded if it can be rebuilt so as to operate efficiently.

FOURTH, every truck in use must be routed to carry as many tons a day as is economically possible. Empty runs must be cut to a minimum.

Owners of trucks and new purchasers should investigate the manufacturers' standing and service facilities which will make it possible for the owner to do his proper share in the responsibility of owning a motor truck.

As manufacturers of THE AUTOCAR MOTOR TRUCK, we are going to live up to our full responsibility and duty as recommended by the War Industries Board.

THE AUTOCAR COMPANY
Ardmore, Pa.

Established 1897

THE ENGINEER AND THE FUEL ADMINISTRATION*

By E. L. COLE
Director Conservation Division, Federal Fuel Administration for Pennsylvania

To the Fuel Administration the co-operation between the engineer and the Administration means the savings in fuel which the present war requires; to the engineer, it means not only this, but also a wider recognition of the economic necessity of engineering advice.

SOON after the declaration of war by the United States against the Central Powers, we were told that "Food will win the war"; a little later, that Liberty Bonds would win the War, and at a belated date, that Fuel would win the War.

Without detracting from the value of these slogans, the Federal Fuel Administration for Pennsylvania emphasizes that until engineers were mobilized and their talents applied to the problem of producing and distributing food and fuel, the financing of which is only possible thru the Liberty Loan campaigns, the actual effect of these slogans was nil.

It is, of course, known to all military authorities that before an army can move forward, the heroic band of men, trained in science and known to the world as engineers—civil, mining, electrical and mechanical—must go before it, in the face of the enemy fire. A striking illustration of the work of engineers was related in the cable despatch of last Friday.

From the city of Pottsville, Pa., the United States Army recruited a company of engineers from the mining, civil, and mechanical circles of the anthracite region. The percentage of casualties among the enlisted personnel of Pottsville and its surrounding territory is higher than that in any other circle.

They made possible the crossing of the Marne by the Allied troops when they pushed back the armies of Germany and her allies, and thrilled each American heart with optimism in the great struggle to enthrone *right* in the place of *might*.

The Fuel Administration, from its very inception, recognized the urgent need and great value of engineering talent in the solution of the grave fuel problems that confronted the nation. This was so from Doctor Garfield all the way down thru the rank and file. However, Congress was not able promptly to perceive this value, and it was only after a serious delay that a small appropriation was made to finance engineering work.

To-day the Federal Fuel Administration in Pennsylvania has, in the person of Mr. George R. Henderson, Administrative Engineer, who is one of the foremost consulting engineers in the United States, an invaluable adviser. He is ably assisted by Charles D. Hickman.

Altho the Administration is hampered by lack of funds, this did not deter it from endeavoring to obtain engineering talent. There is no man in the Federal service who so keenly realizes and has been so ardent an exponent of the value and imperative need of engineers as Mr. William Potter, the Federal Fuel Administrator for Pennsylvania. The number of engineers who are aiding the Administration is a keen source of pleasure to him, and under his direction comes the task of enlisting the generous aid of the foremost engineers in Pennsylvania to act in advisory capacities in the solution of engineering problems allied with the production, distribution, and consumption of fuel.

The Engineering Societies of Pennsylvania are to be congratulated on the keen sense of the duties of citizenship held by their members, who have unhesitatingly come forward at the solicitation of the State Fuel Administration; and their action has been so spontaneous, their activities so co-ordinated, that the fuel authorities at Washington have pronounced the engineering personnel of the Pennsylvania Fuel Administration the foremost in the United States. With the exception of Mr. Henderson and Mr. Hickman, none of the engineers are on a salary basis, but are giving of their time and talent without stint, as a contribution by the scientifically trained citizenship of Pennsylvania towards the successful prosecution of this War.

The results attained by the Fuel Administration thru the expert advice of Pennsylvania engineers can be indicated by the following data:

An oil refining plant will save 40,000 tons of coal annually by the application of improved boiler and engine practice.

Three electric light and railway companies, by introducing stokers and improved condensing apparatus, will save 19,000 tons of coal annually.

One department store is saving 28,000 tons annually thru improvements in its boiler plant.

Three hotels are saving at the rate of 6600 tons aggregate annually thru economies administrative engineers have effected, without detriment to service.

One educational and charitable institution estimated its savings at 2000 tons annually by close economy in the generating of steam and power and its utilization.

Other economies effected are estimated in the aggregate at 200,000 tons annually on the street railways and the office buildings of Pennsylvania.

Other large savings are in prospect.

These figures conclusively show that when a manufacturer, or any other producer, buys coal it is a sound economical proposition for him also to retain engineers

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* Luncheon address Engineers' Club of Philadelphia, Tuesday, August 6, 1918.

The Lehigh
Coal and Navigation Co.

437 Chestnut Street
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No one understands better than an engineer the value of "graphics" for getting an idea "across."

In publications, whether books or advertising, technical difficulties sometimes crop up to apparently prevent the complete and satisfactory illustration of the thought to be conveyed.

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SUPREMACY

is a word that is pretty loosely employed—too often constituting the opinion of the user solely, without reflecting general opinion.

But if supremacy in furnace bridge wall construction implies —as we think it does—an all-around superiority in a business established over a period of years and endorsed by organizations both large and small, then the supremacy of our company and our product—the "Wager Patent Improved Furnace Bridge Wall" —are positively beyond quibble or question.

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to advise him how to obtain the most heating value from the coal.

A fear has been expressed by some engineers that the generous action of Pennsylvania engineers may result in large consumers of coal obtaining expert advice thru the Fuel Administration without cost. It is well known that many prominent manufacturers have hesitated to pay out money for consulting engineers on fuel problems, and the same men are now being benefited by the Fuel Administration. The Administration will readily concede this point. What matters it if here and there a selfish person actually derives financial benefit from the patriotic and generous action of the engineer? It is this very action on the part of the engineers that is dignifying the profession to a larger degree than their best friends anticipated. The Administration and the engineers, working hand in hand, are gradually educating all buyers of coal to the economic necessity of engaging engineering talent to guide them on all combustion problems connected with the generation of steam and electrical power, and the utilization of all kinds of power in industry.

The day of cheap fuel has passed into history—it is extremely doubtful that it will ever return. This is true whether the fuel be natural gas, crude oil and its by-products, or anthracite and bituminous coal. At the close of the war the United States will undoubtedly be found carrying the major portion of the world's trans-Atlantic traffic. In no port in the world will bunkers be filled with coal at a lower cost than on the shores of this country. It is logical, therefore, to say or to predict that vessels steaming from our ports will be bunkered for round trips. This alone will require an immense tonnage of fuel, and will be a strong economic basis upon which the engineers will be able to build an increasing practice as consulting experts. Buyers of fuel will learn before the war is over that war and post-war taxes may in many cases be paid out of the savings effected thru the service of engineers. In a few isolated cases some of the largest consumers of fuel in Pennsylvania are already paying their Federal taxes from savings effected in the combustion of fuel and the conserving in the use of light and power as pointed out by the Administration engineers.

There can be no question that when the war is fought to a successful conclusion, and *right* is securely enthroned in the courts of Europe as it is now in the minds of all free men, and the Fuel Administration ceases to function, its members again taking up the pursuits of peaceful times, the engineers of Pennsylvania, thru their generous contribution of talent thru the war, will have unconsciously built for themselves a rich heritage wherein their sphere of activities will be largely increased because hard-headed business men will have larger vision, and every step in industry will be held up until engineers have determined that it is economically sound, whether it be the combustion of fuel or the utilization of energy.

The Federal Fuel Administration for Pennsylvania expresses its appreciation and deep sense of obligation to the engineers for the work that has already been accomplished by them, and confidently anticipates that when its work is done, whatever economies may have been effected will be due almost entirely to your having voluntarily undertaken the tasks at home that are parallel with the tasks that your brothers are so well doing on the field of honor.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

SEPTEMBER MEETING

Date: Monday, September 16, 1918.
Place: Bellevue-Stratford Clover Room.
Subject: Electric Welding—A new industry.
Speaker: H. A. Hornor.

Soon after our country entered the war, a Committee on Electric Welding was appointed by the Institute to get together and supplement present knowledge on the art of electric welding. This committee was later merged with the Emergency Fleet Corporation and became a committee of that organization.

Owing to the enormous advantages to the steel shipbuilding industry presented by the art of electric welding, this committee has been carrying on a very active campaign of education and investigation and it is the purpose of this meeting to present the entire subject in careful outline to the engineering field in the "Territory of the Delaware."

It is for this reason that a joint meeting has been arranged to include the Engineers' Club and the Association of Iron and Steel Electrical Engineers. As the convention of the latter organization is to be held in Baltimore the few days preceding this meeting, it is expected that many of the out-of-town members will attend the Philadelphia meeting.

Mr. Charles M. Schwab will be present at this meeting and will open the session. Mr. Schwab will also be present at the informal dinner which will be held in the Stratford Room at the Bellevue-Stratford Hotel preceding the meeting and will give an informal talk.

PROGRAM

6 P.M.—Dinner, Stratford Room.
8 P.M.—Meeting, Clover Room.

E. B. Tuttle,
Secretary.

Speeding the Kaiser's Doom with Link-Belt Electric Hoists

THE early arrival of World Wide Democracy depends as much on speedy production by American industries as speedy landing of American soldiers in France.

Link-Belt Electric Hoists are helping to speed up this production in all parts of America. They are "doing their bit" in every line of industry. And they are proving powerful factors in reducing production costs.

They can be easily, quickly and inexpensively installed in old or new buildings. Monorail tracks can be attached to ceilings or girders anywhere. Little head room required. All parts are fully enclosed in dust proof, weather proof casings. They can be operated outdoors as well as indoors. Made in various capacities—floor or cage operated.

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145

LINK-BELT

ELECTRIC HOISTS

SECRETARY'S NOTICES

SPECIAL MEETING OF THE BOARD OF DIRECTORS OF THE ENGINEERS' CLUB OF PHILADELPHIA

AUGUST 6, 1918

The meeting was called to order at 5.15 P.M., with President Stevens, Vice President Eglin, Directors Connell, Long, Spencer, James, Lauer, Quimby, Douglas, Newkirk, Treasurer Kenney and Secretary Stockly in attendance. Mr. Wm. Pool Parker, Chairman of the Committee on House, was also present, on request. Vice Presidents Andrews and Wagner, Directors Gant, Swaab, Murphy, Barr, Past Presidents Ledoux and Vogleson were excused. Directors Lee, Terrell and Past President Carter were absent.

REPORT OF THE PRESIDENT

The President announced that the Secretary had obtained a five-year extension from the holders of the first mortgage on 1317 Spruce Street, the interest to be at 6 per cent., instead of 5.4 per cent., as at present.

The President further announced that the Secretary had obtained assurance from the Old Colony Building and Loan Association of Philadelphia of a $17,000 loan to the Club on a building and loan mortgage placed on the Club properties at 1315 and 1317 Spruce Street, the conditions specified being those usual to a building and loan mortgage, namely, in this case that the Club subscribe to 85 shares of stock, payable monthly at $1 per share, together with interest on the $17,000 loan at $85 per month; and as an additional guarantee that 85 other shares in the same series be subscribed to by members of the Club and assigned to the Building and Loan Association until the liquidation of the loan.

By this procedure, it would be unnecessary to raise $25,000 in scrip, about $7600 worth being sufficient.

The Club being an incorporated organization, the President announced that it would be necessary for the Club, in business meeting, to adopt the necessary resolutions authorizing this loan; and the following resolutions, which had been put in shape by Mr. Long and approved by the Land Title and Trust Company, thru whom the settlement would be made, were approved by the Board, with their recommendation that they be presented to the Club at its business meeting on August 12th.

Whereas, The Engineers' Club of Philadelphia is indebted to various creditors in the sum of $24,652.58, being balance due on improvements to the Club house; and

Whereas, the balance of cash on hand in the Building Fund is not sufficient to meet these obligations; therefore, be it

Resolved, That in order to assist in raising sufficient funds to discharge the foregoing obligations, the Board of Directors is hereby authorized and directed to borrow from a Building and Loan Association to be selected by them a sum not exceeding $17,000; and be it further

Resolved, That for the better securing of the said sum so borrowed, the Board of Directors is hereby further authorized and empowered to subscribe to and make payments as called for on eighty-five shares of stock of said Building and Loan Association and to execute and deliver to such Building and Loan Association a mortgage upon the property of the Club upon such terms and conditions as may be required by the said Building and Loan Association; and be it further

Resolved, That the Board of Directors be and is hereby given and vested by the Club with full power and authority in its name and behalf to do and perform all necessary acts and things, and to authorize the execution of such papers and instruments as may be necessary to carry out the provisions of this resolution and all and every matter and thing they shall do in said premises is hereby ratified and confirmed.

Whereas, The Engineers' Club of Philadelphia, being indebted to various creditors in the sum of $24,652.58 on account of improvements to the Club house, and the Board of Directors having made provision for the financing of a portion of this indebtedness through a Building and Loan Association mortgage; therefore, be it

Resolved, That for the purposes of meeting the balance of these obligations and for general improvements to the Club house, the Board of Directors be and the same is hereby authorized and directed to proceed to issue and sell Scrip of the Club for a sum not exceeding $23,000, bearing interest at the rate of 6 per cent. per annum, said Scrip to be issued in denominations of $100 or any multiple thereof and dated as of September 1, 1918; and be it further

Resolved, That the Treasurer of the Club be authorized to set aside as a sinking fund for the retirement of such Scrip the net proceeds derived from the sale of future Life Memberships, and also any other funds of the Club that the Board of Directors may from time to time authorize to be placed in said sinking fund; and be it further

Resolved, That the Scrip issued in accordance with this resolution be retired at the convenience of the Club out of the proceeds of said sinking fund to be established from sale of Life Memberships, Scrip to be retired to be drawn by lot on interest-bearing dates, and the holders thereof notified and all interest to cease upon such Scrip when drawn for retirement.

REPORT OF THE COMMITTEE ON MEMBERSHIP

On the recommendations of the Committee, the Board transferred Mr. Samuel L. Schwartz from Junior to Active membership, under the provisions of Article I, Section 4 of the By-Laws; and elected the following applicants:

To Active Membership

James G. Calebaugh
Thomas W. Clarke
John J. A. Devine
James P. Harbeson, Jr.
Witold Lesniewski
Ralph L. Lovell
Robert J. Lyons
Linn O. Morrow
Charles W. Parkhurst
Edward P. Roberts
David T. Williams

To Junior Membership

Edward M. Murphy

The meeting adjourned at 6.15 P.M.

H. A. STOCKLY,
Secretary.

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PHILADELPHIA, PA.

STEAM LOCOMOTIVES

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GASOLINE LOCOMOTIVES

for light industrial, contractors' and switching service

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DELIVERIES BY TEAM, RAIL AND BARGE

VULCANITE PORTLAND CEMENT

THE BRAND WITH A REPUTATION

Land Title Building
Philadelphia

COMMITTEE ON MEMBERSHIP

PAUL SPENCER, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before September 9 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

SYDNEY BUCKLEY

Meadow and Mifflin Sts. (care of Niles-Bement-Pond Co.), Philadelphia.

Chief Engineer, Crane Dept., Niles-Bement-Pond Co.
Proposed by Victor O. Strobel and Wm. C. L. Eglin.

LEWIS G. GILLETT

6141 Nassau St., Philadelphia.

Assistant Engineer, U. S. Shipping Board, Emergency Fleet Corporation.
Proposed by E. F. Cobb and H. T. McGaughan.

CHARLES D. HICKMAN

2416 Bryn Mawr Ave., West Philadelphia.

Assistant Administrative Engineer, Federal Fuel Administration for Pennsylvania.
Proposed by J. F. Stevens and H. F. Sanville.

RAY L. SOMERS

Upper Montclair, N. J.

Resident Inspector, U. S. Shipping Board, Emergency Fleet Corporation.
Proposed by E. F. Cobb and H. T. McGaughan.

FOR ELECTION TO JUNIOR MEMBERSHIP

T. J. EARLEY

4211 Otter St., Philadelphia.

Salesman, Concrete Steel Co.
Proposed by W. L. Whitman, 2nd, and G. E. Dale.

POSITIONS OPEN

Wanted.—Young sales engineer, with experience in power plant equipment. Technical graduate preferred. Excellent prospects.

Apply 223-A, Engineers' Club.

Wanted.—Mechanical draftsman, experienced in plant engineering, building construction and water power plant development; must be familiar with use of surveying instruments.

Apply 228-A, Engineers' Club.

Wanted.—Mechanical draftsman wanted for manufacturing ignition systems. Desirable but not necessary that applicant have some knowledge of electricity. Must be good draftsman, capable of some designing.

Apply 229-A, Engineers' Club.

Wanted.—A first-class electrical engineer for work on a barge.

Apply 234-A, Engineers' Club.

Wanted.—Structural and architectural draftsmen.

Apply 235-A, Engineers' Club.

Wanted.—Graduate engineer about 30 years of age for estimating on steel welded tanks. Must have knowledge of electricity, steam and hydraulics. Salary commensurate with ability.

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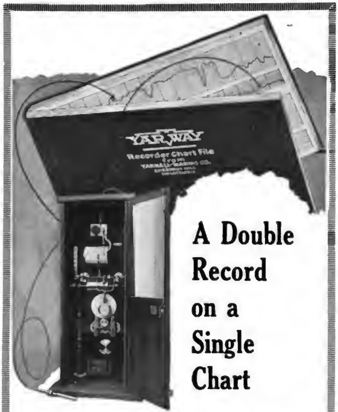

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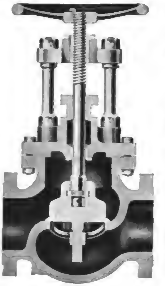

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Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, H. Butler	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, via New York
Allen, J. G.	Co. 12	Infantry, Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Anders, D. W.	Major	Company D, 502nd Engineers	American Expeditionary Forces, France
Andrews, J. H. M.	Major	Ordnance R. C.	Commdg. Officer, Raritan River Ordnance Depot, Metuchen, N. J.
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Austermuhl, Edward	Utilities Officer	War Department	203 South 4th Street, Philadelphia
Baird, Hobart B.	Captain	307th Engineers	American Expeditionary Forces
Baker, W. D.	2nd Lieutenant	Aviation Corps	France
Banister, E. S.	Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Barnes, H. P.		Naval Flying Corps Mass. Inst. Technology	Cambridge, Mass.
Barnes, F. B.	Master Engineer	Care of S. E. O., A. S., S. O. S. Electrical and Mechanical Department	American Expeditionary Forces, via New York
Bassett, F. H., Jr.		Officers' Training School	Camp Meade, Md.
Bauman, C. W.	Lieutenant	Co. "E" 103rd Engineers	American Expeditionary Forces, via New York
Bear, H. K.	Lieutenant	Gas Defense Service	Camp Greenleaf, Ft. Oglethorpe, Ga.
Beatty, L. B.	Ensign	U. S. Naval Reserve Force	705 Parker Ave., Collingdale, Pa.
Bell, Frank F.	1st Lieutenant	Signal Corps, Aviation Section	Gerstner Field, Lake Charles, Louisiana
Bescherer, P.	2nd Lieutenant	319th Heavy Artillery	Camp Gordon, Ga.
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Biester, W. H., Jr.	Corporal	"Co. E," 103rd Engineers	American Expeditionary Forces, via New York
Bishop, A. B.	Lieutenant	Dept. Military Aeronautics	Camp Jackson, Columbia, S. C.
Booz, H. C.	Colonel	In Charge of Construction of Railroads, Wharves, etc.	Amer. Exped. Forces, via New York
Borden, J. M.	2nd Lieutenant	Ordnance Reserve Corps	Hudson Motor Car Co., Detroit, Mich.
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. F.	Lieutenant Engineer Officer	U. S. Naval Reserve Force	Submarine Base, New London, Conn.
Boyd, G.	1st Sergeant	Gas Service	A. P. O. 717, American Expeditionary Forces, via New York
Bradford, J. S.	Major	103rd Engineers	American Expeditionary Forces, via New York
Bradt, Morris	1st Lieutenant	Ordnance Officers' Reserve Corps	Hqrs. Base Section No. 3, Line of Communication, A. E. F., Goring Hotel, Grosvenor Gardens, London, S. W. 1
Bransome, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
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Breen, J. W.	Captain	Engineers U. S. R.	A. P. O. 702, Amer. Exped. Forces, via New York
Brewer, P. C., Jr.	2nd Lieutenant	307th Engineers	American Expeditionary Forces, via New York
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Britten, D. L.	Captain	Ordnance Officers' Reserve Corps	Inspector of Ordnance, Haddon Apts., Cleveland, O.
Broadhead, Alex		19th Reserve Engineers	American Expeditionary Forces, via New York
Brogan, C. M.		Quartermaster's Corps, Utility Detachment, Barracks "B"	Camp Meade, Admiral, Md.
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Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier-General W. W. Atterbury
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Brown, R. V.	Lieutenant	Q. M. C., N. A., Advanced Section	S. O. S. American Expeditionary Forces, France
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Faust, W. D.		103rd Engineers	American Expeditionary Forces, via New York
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Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	P. O. 717, American Expeditionary Forces, France
Galloway, James W.	Private	Co. B., 103rd Engineers	American Expeditionary Forces, via New York
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Gillam, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Goldsmith, H. F.		Naval Aviation Training School	Cambridge, Mass.
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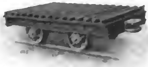

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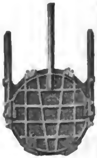

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Meyers, W. C.	Captain	Ordnance Officers' Reserve	Inspection Division Westinghouse Elec. & Mfg. Co. Shadyside, Pittsburgh, Pa.
Millar, E. A., Jr.	1st Lieutenant	Ordnance N. A.	Camp Hancock, Augusta, Ga.
Mohr, C. F.	Private	Co. "B," 45th Engineers	Camp Humphrey, Va.
Moody, Wm. M.		Reserve Officers' Training Camp	Fort Oglethorpe, Ga.
Moon, T. E.	Sergeant	Barracks C—19, O. O. M. I. S.	Raritan Arsenal, Metuchen, N. J.
Moran, J. B.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Muench, W. O., Jr.	1st Lieutenant	Co. No. 1-4, E. O. T. C.	Camp Lee, Va.
Murphy, H. C.	Ensign	U. S. Navy	Bureau of Ordnance, Navy Dep't, Washington, D. C.
Mustin, Samuel	1st Class Yeoman	Care of Public Works Officer, U. S. N.	Cape May City, N. J.
Myers, W. T.	2nd Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Newlin, E. M.	1st Lieutenant	312 Machine Gun Battalion	Camp Meade, Admiral, Md.
Newlin, J. C.	Major	Engineer Officers' Reserve Corps	Amer. Embassy, London, care of Vice-Admiral Sims
Nixdorf, F. S.		5th Company, Coast Artillery Officers' Training Camp	Fort Monroe, Va.
Nixon-Miller, M.	Captain	Captain Com'd'g Co. A. 19th Engrs. (Rwy)	American Expeditionary Forces, via New York
Noyes, S. H.	1st Lieutenant	1st Aero Squadron	Columbus, N. M.
*Oakes, J. C.	Colonel	113th Engineers	Camp Shelby, Hattiesburg, Miss.
O'Connor, Chas. P.	Captain	19th Engineers (Rwy.) U. S. R.	American Expeditionary Forces, via New York
Orr, M. W.	2nd Lieutenant	Field Artillery, Separate Detachment	American Expeditionary Forces, via New York
*Otwell, Curtis W.	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Perry, Edward	Sergeant	Motor Truck Company No. 329	Camp Lee, Petersburg, Va.
Peterman, J. M.	2nd Lieutenant	5th Bn., 152nd Depot Brigade	Camp Upton, N. Y.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pickles, W. W.	Chief Sanitary Inspector	American Red Cross Sanitary Unit No. 25	Extra Cantonment Zone Sanitation, City Hall, Augusta, Ga.
Pierce, D. T.		American Red Cross	France
Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Prichett, F. B.		103rd Trench Mortar Battery	American Expeditionary Forces, via New York
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rawcliffe, J. F. B.	Lieutenant	79th Field Artillery	Houston, Texas
Raynsford, C. O.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Reed, R. W.	Private	Hqrs. 19th Reserve Engineers, Railway	Amer. Exp. Forces, via New York
Reed, Thomas	Major	Ordnance U. S. A.	Inspector of Ordnance. The Singer Mfg. Co. Elizabethport, N. J.
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Reninger, H. A.	Major	Headquarters, 103rd Ammunition Train, 28th Div.	Amer. Exp. Forces, via New York
Ridge, R. S.	Sergeant	Co. "A," 23rd Engineers	American Expeditionary Forces, via New York
Ridgway, J. J.	1st Lieutenant	Co. "F," 318th Infantry	Camp Lee, Petersburg. Va.
Ritchie, J. M.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Rogers, C. B.	Private	201st Aero Squadron	American Expeditionary Forces, via New York
Rogers, J. I.	Lieutenant	United States Naval Reserve Force	U. S. S. Vestal, in care of Postmaster, Fortress Monroe, Va.
Roop, J. C.	Captain	17th Engineers	American Expeditionary Forces, via New York
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Ruff, A. G.	Ensign	U. S. Naval Reserve Force	Quarters "B," Naval Academy, Annapolis, Md.
Russell, J. A.	Lieutenant	311th Engineers	Camp Grant, Rockford, Ill.
Ryan, E. J.	1st Lieutenant	T. C. N. A.	American Forces Woraret Camp, Wareham, England.
Sacks, S. I.		Material Corps, U. S. N. Reserve Force	
Sanville, L. F.	Private	108th Field Artillery, Penna. Troops	American Expeditionary Forces, via New York
Satterwhite, R. L., Jr.		Company 20, Naval Aviation Detachment	Massachusetts School of Technology Cambridge, Mass.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	New York Arsenal, Governor's Island, N. Y. Harbor
Schaum, O. W.	Aeronautical Mechanical Engineer	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
†Schoch, J. B.	Lieutenant	109th U. S. Infantry	American Expeditionary Forces, via New York
Schoff, A. L.	1st Lieutenant	Signal Corps, Land Division	Fort Worth, Texas
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defense Service, Med. Dept., U. S. A.	Washington, D. C.
Scull, M. A. H.	Lieutenant	Railroad Transportation Corps	U. S. A. P. O. 717, American Exp'y Forces, via New York
Shallcross, J. B.	Lieutenant	Ordnance Reserve Corps	Inspection Div., 6th & B Sts., N. W., Washington, D. C.
Shoemaker, Frederick F.		U. S. S. Suzanne, S. P. 510	Cape May, N. J.
Sheahan, J. C.	2nd Lieutenant	M. T. S. A. P. O. 708,	American Expeditionary Forces, via New York
Shuster, W. H., Jr.	Lieutenant	314th Infantry	Camp Meade, Md.
Sigmund, Paul E.		1st Replacement and Training Regiment of Engineers	Washington Barracks, Washington, D.C.
Smith, A. H.	Sergeant	Utilities Detachment Quartermaster's Corps	Barracks B 104, Camp Meade, Admiral, Md.
*Smith, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
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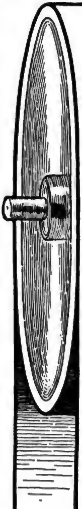

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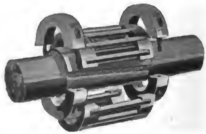

Spackman, H. S.	Major	Engineer Officers' Reserve	A. P. O. 702, American Exp'y Forces, via New York
Spillan, J. J. D.	2nd Lieutenant	103rd Trench Mortar Battery,	American Expeditionary Forces, via New York
St. John, Everett	1st Lieutenant	Coast Artillery Reserve Corps	Fort duPont, Delaware
Stevenson, W. L.	Lieutenant Commander	U. S. Naval Reserve Force	Care of American Consul, Bordeaux, France.
Stokes, D. B.	Major	Quartermaster's Corps, N. A.	Care of Hotel Burlington, Washington, D. C.
*Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	Major	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Co. "A" 32nd Engineers,	American Expeditionary Forces, via New York
Thacher, C. H.	2nd Lieutenant	Co. "A" 510 Engineers' Service Battalion	American Expeditionary Forces, via New York
*Thomas, R. S.	Colonel	22nd Engineers	Camp Sheridan, Montgomery, Ala.
Thomson, H. A.	1st Sergeant	Penna. Quartermaster's Corps	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Corporal	Ordnance Detachment "B"	Gunpowder Reservation, Edgewood, Md.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Florida" (foreign service)
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Truhan, L. J. D.	Ensign	U. S. Submarine Base, Barracks "E"	New London, Conn.
Uhler, W. D.	Major	Quartermaster Corps, N. A.	Washington, D. C.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal
Vaughan, D. L.	Captain	Quartermaster's Corps N. A.	Camp Logan, Houston, Texas
Voegelin, E.		10th Company	Barracks, Columbus, Ohio
Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Hqr's, 34th Artillery Brigade	Fort Adams, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces, via New York
Warfel, J. P.	Senior Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Captain	Engineer Officers' Reserve Corps	
Webb, Walter Loring	Major	R. R. & C., S. O. S.	American Expeditionary Forces, via New York
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Wheeler, Robert C.	Captain	Quartermaster's Corps.	594-96 Drexel Building, Philadelphia
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	Camp Jackson, Columbia, S. C.
White, W. M.	Captain and Regimental Adjutant	103rd Engineers	American Expeditionary Forces, via New York
White, J. A. Jr.	Private	20th Division 109th Infantry	American Expeditionary Forces, via New York
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	War Department, Washington, D. C.
Wilkinson, R. W.		Engineers' Training School	Carnegie Institute, New York
Williams, H. L.	2nd Lieutenant	Engineer Officers' Reserve Corps	Corpus Christi, Texas
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Worrwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps.	Office of Inspector of Ordnance, U. S. A. Ford Motor Co., Highland Park, Mich.
Wood, E. R. Jr.	Captain	18th Field Artillery, N. A.	
Work, Leonarn	1st Lieutenant	52nd Aero Squadron, A. S. S. C	American Expeditionary Forces, via New York
Worrell, H. S.	Lieutenant	Coast Artillery School	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Santa Fé, N. M.
Young, R. L.	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Aberdeen, Md.
Zeckwer, J. R.	Ensign	U. S. Naval Reserve Force	Ship Inspection Office, Philadelphia
*Zinn, George A.	Colonel	District Engineers' Office. Custom House	Portland, Oregon

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* Army and Navy member.

JUNIOR SECTION

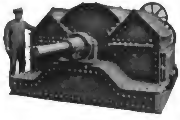
WILMER Z. KLINE, Chairman

The regular monthly meeting of the Executive Committee of the Junior Section was held on Thursday evening, August 15th.

It was decided that at the first regular meeting of the Section there would be a smoker, at which we would have a prominent speaker address us on one of the vital questions of the day.

Do not forget the first regular meeting on October 8th. Come yourself and bring a friend.

It is with feelings of the deepest sorrow that we learn of the death of two of our fellow Junior Members, Sergeant Edward W. Barker and Lieutenant Harry W. Prince, who lost their lives in the service of our country. The Secretary has been requested to send letters of condolence to their parents.



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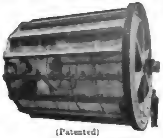

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THE
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VOL. XXXV-10 OCTOBER, 1918 NO. 167

THE EARLY HISTORY OF AMERICAN SHIPBUILDING

A review of the history and practice of shipbuilding in the United States prior to 1880, as compiled from the memoirs and papers of the late Mr. Charles M. Cramp, the report on shipbuilding in America by Mr. Henry Hall, and the personal experiences of the author.

By W. A. DOBSON, Member*

FISHING VESSELS

FISHING vessels properly come first in any account of the American shipbuilding industry, since fishing vessels are the starting-point of our shipbuilding and merchant service, as they have been historically in the case of every nation which has been conspicuous upon the sea. In this respect America has followed the path of all of her predecessors; and it was the steps she took in this direction which led originally both to the possession of her large fleet of fishing boats and vessels and to her success in the field of general nautical enterprise.

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U. S. S. "HARTFORD"

The first steps in the development of the fishing business of America, and the attendant shipbuilding industry, was that which led to the crossing of the Atlantic by European fishing craft and the planting of small establishments on shore by their crews At the time of the settlement of the north Atlantic coast fish were in great demand abroad and brought high prices. In 1497 Cabot made known in Europe that the ocean in the neighborhood of the northern part of this continent was full of fish of a size then seldom seen in the old country. "Here," he said, "were great seals, and those which we commonly call salmons, and also soles above a yard in length, but especially there was a great abundance of that kind which the savage called baccalos, or codfish."

The first vessels sent to America to fish were among the largest of their time in the merchant service of England, France and Portugal. As illustrating the size of those early vessels, it is stated that of the 1,232 sail which in 1582 comprised the whole marine of England not over 217 were over 80 tons actual burden; that is to say, not over 75 feet in length by about 23 feet in breadth, and about 10 feet in the hold.

The first vessels sent from New England to the banks to fish set sail in 1645, and comprised "a ship and other vessels," their rig not known; but a style of smack which became popular as soon as something larger than the shallop was required was the "catch," or "ketch." The Dutch called them the "pinkie," a name borrowed from the Mediterranean and meaning a hull round at both ends, the outside planking ending on the stem and on the sternpost, in distinction from ships having a broad or "square" stern above the water, which were planked straight across.

In 1745 Andrew Robinson, of Gloucester, built a vessel with square stern, which was fitted with two masts, bearing a sloop sail on each and a bowsprit with jib. She was sharp on the bottom and fast, and, on being launched, sped over the water so fast from the impetus gained by descending from the ways as to elicit from a bystander the remark, "See how she scoons!" "Scoon" was a word used by plain people to express the skipping of a flat stone over the surface of the water when skillfully thrown, and the builder of the vessel, having been somewhat at a loss for a name for the new rig, seized upon the trifling incident referred to and replied, "A scooner let her be," and two-masted vessels, with jibs and fore and aft sails, have since been called by that name. The advantage possessed by the "schooner" (as the name is now spelled), is that the canvas of the vessel is divided into a large number of sails, which are more easily handled than the large sails of a sloop could be, each containing the same amount of cloth. The schooner quickly superseded the sloop in the bank fisheries and in all others requiring voyages of any distance. Since the Revolutionary War they have been the only vessels employed by Americans in the banks fisheries.

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* Naval Architect, The Wm. Cramp & Sons Ship and Engine Building Company.

The clipper schooner represents the next development. A few good years, in which fish were plenty and prices profitable, and the anxiety to make rapid trips and as many as possible in one year, led to great improvements in form. The body of the vessel was made leaner and sharper under the water, the bow longer and finer, the run cleaner, and the angle of entrance forward was sharpened from 85° to 45°. The spars were lengthened, and the schooner put under a heavier press of canvas.

From this beginning have developed the magnificent four- and five-masted schooners of the present day, which are often equipped with auxiliary motors, and steam gear for handling sails and loading apparatus.

MERCHANT SAILING VESSELS

Nature having fitted this continent for shipbuilding by supplying it with an abundance of good timber, vessels have been built upon our shores from the first year of actual settlement, the first ship, oddly enough, having been constructed to carry a little band of settlers away from an inhospitable region which they wished to leave after their first winter. This vessel was built at the mouth of the Kennebec River, in Maine, a region which has since become famous for its ships, and which is now one of the leading localities for the construction of wooden sailing ships and torpedo boats of high speed.

PANORAMA CRAMP'S SHIPYARD IN 1872

Shipbuilding flourished in Philadelphia, Baltimore, and Charleston to some extent before the Revolutionary War. Vessels were fitted out by their merchants chiefly for foreign trade, and while not remarkable for number the shipping of these ports was well built and well modeled. Philadelphia was always active in the West India trade, and at one time had almost entire possession of the East India trade of this country.

During the Revolution shipbuilding was nearly suspended. English cruisers hovered near our coasts and captured and destroyed large numbers of vessels, the whaling and fishing fleet being almost annihilated. Foreign trade suffered the same fate. Raids were made on various coast towns and the shipping in port was burned; it was not safe to send anything excepting an armed vessel to sea, and few, except privateers, intended especially for preying upon English merchantmen, were fitted out at any American port.

After 1783 American ships were foreign vessels in the eye of British law. Cut off at once from a part of the trade which they had enjoyed before the Revolution, they were compelled to go into the fields of employment which were open to them, and the East India and Asiatic trades being free, our larger merchantmen went into them at once.

March 3, 1815, Congress passed a law forbidding any foreign vessel to bring goods to America, except from the country to which it belonged. This act was the legislative weapon by whose unsparing use we were enabled in the course of a few years to obtain from every foreign nation a treaty of reciprocity in trade and to break down, one by one, the vexatious obstructions of foreign law to the free enterprise of American citizens in the carrying trade of the world. The legislative annals of Congress contain the complete record of this struggle and the victory. After 1815 our maritime career was one of great prosperity.

The bulk of American tonnage during the period from 1814 to 1860 was employed in general freighting and passenger carrying between this continent and the Eastern world, and some of it to and from South America. It was into this general trade that the fast privateers of 1812-14 went after peace, and in which they were steadily engaged until they were worn out, which was in about twenty years' time, when they were succeeded in general freighting by a fuller class of ships, carrying large cargoes and spreading a vast expanse of canvas. It was required that the vessels should carry the greatest number of tons of goods on a given draught of water consistent with stability under sail, and rolling easily in a sea-way, steering well, and sailing fast, and there was great difficulty in deciding upon a model which would answer all the multifarious demands of trade, as there was a wide variety in cargoes. Sometimes the charter would be for a cargo of railroad iron; sometimes for teas and East India goods; sometimes for grain and flour and naval stores; at other times for a miscellaneous cargo. A good average style vessel, which would do fairly well under any circumstances, was the best result that could be attained so far as model was concerned, and builders always found it safe to err on the side of capacity to carry a little larger and heavier cargo than was called for. The tendency was decidedly toward full ships, the old plan being followed of locating the dead flat, or largest section of the ship, at two-fifths the length from the bow. The round floors and the long turn of the bilge, lingering from the preceding century, gradually gave way to flatter floors and a sharper turn of the bilge; the huge swell of the sides was slowly abandoned; figure-heads were left off; the bow was made flaring above water; more sheer was given; the center of buoyancy was moved farther aft; and the handsome freight carrier used between 1845 and 1860 came into existence in consequence of the successive changes introduced.

THE PACKET SHIP

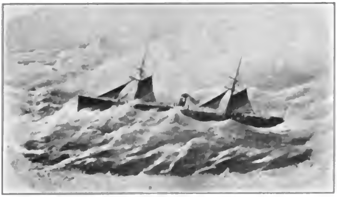
A great many houses in Portland, Boston, New York, Philadelphia, Baltimore, Norfolk, Charleston and New Orleans put their money into ships especially built for the passenger service, and ran them in regular lines to all the ports abroad and on our own coast whither trade and travel chiefly tended. In the coasting trade, brigs, schooners and barks were used, but in the packet service to foreign ports, barks and ships only were thought of. The latter were vessels of the largest size, handsomely built and sumptuously fitted up, and carried often 600 to 1,000 persons and 1,000 tons or more of freight. The lines to Liverpool, Havre, and Australia often comprised 15 or 20 vessels, each, of the finest specimens of maritime architecture afloat. A line famous in the history of the Delaware was the "Cope Line," between Philadelphia and Liverpool. When the clipper era began the packets improved in speed and made trips across the ocean to Europe and to Australia which it took the steamships years to surpass. These lines were owned chiefly in the north by old shipping houses of great experience and large capital.

It was at New York that the packet business between America and Europe chiefly centered. There were celebrated lines from other ports, but New York was the pioneer and always kept the lead, and had the most and finest packets. The New Yorkers were restless under their dependence on the old English ships sailing to Falmouth, which ran only in the winter time, and besides were slow. In the summer time they sailed from Halifax. It was resolved to run an American line from New York, and a start was made a year or two after the war of 1812 by Isaac Wright & Co., with the four ships, Pacific, Amity, James Cropper and William Thompson, of from 400 to 500 tons each. These packets constituted the Black Ball Line, so called from the round black dot in a white field which was adopted as the pennant of the ships. They were put at once into the packet business to Liverpool, sailing the first of every month, and made the run outward in an average of 23 days, and the homeward run in 40 days. The ships were well built, fleet, and handsome, were managed with great energy, and were successful from the start. In about six months four vessels were added to the line, sailing on the 16th of every month, and each made three round trips a year. The Black Ball Line remained in existence, though changed in ownership, until the decline of American shipping finally terminated its career, and was one of the last to surrender the field to the new monarch of the sea, steam.

The New York and Philadelphia packets were all superior vessels, and were commanded by a remarkably fine class of men, the best families on the shipbuilding coasts contributing men to officer these ships. The frequency and regularity of their sailing were strong points. Toward the last there was a packet sailing every five

U. S. S. "NEW IRONSIDES"

days. No foreign vessel got the mails in those days, as they were all given, at least by the American Government, to American packets; and so great was the reputation of these vessels that they were regularly patronized not only by Americans going abroad, but by the West India merchants, Canadians, and even English officers of the large garrisons in Halifax and the provinces generally. These packets drove nearly all foreign rivals out of the business. Many efforts were made to compete with them, but never with any success.



AMERICAN LINE "INDIANA"

The first three-decker was the Guy Mannering, of 1,419 tons, which was built in 1849 by William H. Webb, at New York—a noble structure and a good ship. Three-deckers, with poop and top-gallant forecastle decks, were afterward the popular style of packet. The Guy Mannering was 190½ feet long, register measurement, 40⅘ feet beam, and 28⅔ feet deep in the hold. At 20 feet draught above the keel she would carry 2,400 tons of cargo. Her greatest beam was at two-fifths of the length from the bow. The lower water line at bow and stern were concave, and at the plank-sheer and rail the bow was almost round.

The American packets carried the best officers and the largest crews of any ships afloat. They were fast, dry, handsome, and sumptuously fitted up, and were managed with so much energy, care and ability that they gained a virtual monopoly of the passenger, mail, and express traffic to Europe. They made the best time of any ships afloat, were insured at the lowest rates and earned the highest freights, and superseded nearly all the English, French, and German ships in that business, and their success and fame were the subject of intense envy abroad.

THE INCEPTION OF SCIENTIFIC SHIPBUILDING

In the construction of these vessels the best talent of the day was employed and they were generally built for the owners by contractors who had already attained some celebrity. The rivalry of the various lines was keen, and it was this eager competition as much as anything else which led to the continual improvement in models, rig, workmanship, and general excellence of American ships, each vessel being expected to excel some rival or all the predecessors of its own fleet in some desirable quality. Builders found that more was required of them than at any previous period of their history, and in order to hold their own and maintain the reputation of their yards they were forced to study the scientific principles involved in the form and sparring of ships.

After 1815 the designers and builders of packets could not afford to remain in ignorance of the fundamental principles of their art. They did not sufficiently know what made one ship bad and another ship good, and therefore began to study. They sought every source of information. Books were imported from Europe, and many builders went to school to the constructors of the American navy. Delicate tests were made with small models of different forms; fast fish were cut up, and their shapes analyzed; the flow of waves from the bow of a boat was investigated, and every other conceivable point was looked into. Model tanks and the law of comparisons were unknown, but to judge of the comparative resistances of two models, both of which had their good points, the models, made to scale, were towed in still water attached at equidistant points to a balanced lever or whiffletree. The model which lagged behind was adjudged loser, as the greater resistance caused it to fall astern. The period from 1815 to 1850 was thus one of study, experiment, and discussion, especially in the large cities, and, in consequence, there grew up a race of acute and daring shipbuilders, whose achievements were the wonder of the world, and whose fashions were imitated, both on this and the other side of the ocean, by everybody who built ships.

The qualities desired in a packet ship were strength, speed, stability at sea, ease of handling, easy rolling, beauty of model, and comfort in the passenger accommodations. It must not be supposed that these were all attained at one bound; on the contrary, the best good general model for the packet ship, and the best sizes and dimensions of timber, were reached only by patient study and slow degrees. A great many bad ships were built before all the questions that interested the building world were decided; but it was the final result of the forty years of study and investigation following the War of 1812 that the sailing ship reached substantial perfection as an ocean carrier.

One of the ablest of the Navy Constructors at this period was Mr. Joshua Humphreys, of Philadelphia. Mr. Humphreys designed some of the best fighting vessels of the day. It was his practice to rate his vessels in the prevailing terms of the day, say 75 or 100 gun frigates, but he invariably carried 10 to 12 per cent. more guns than rated. He was evidently a believer in the theory that Providence is on the side of the heavier artillery. I have seen some of Mr. Humphreys' original work and noted with admiration the care with which the lines, the balance of buoyancy, the effort of the sails in manœuvring, and many other features were worked out, not in accordance with the well-known principles of to-day, for knowledge of them did not exist, but in accordance with personal experience gained by keen observation and comparison of performances.

Good ships are necessary to maritime eminence, but good sailors are equally required. The great prosperity of our shipping from 1814 to 1861 was due in large measure to the excellent personnel of the crews and officers of the merchantmen. These people were recruited in the main from the fisheries and the coasting trade. The majority were American born, having homes and families ashore, and were persons of good principles, abstaining especially from the use of spirituous liquors. Sailors were paid good wages, and the captains were spurred by the payment of a percentage of the freight and passage money as a premium. A good crew means energy on board ship, quick voyages, the saving of time in getting into and out of port, the rescue of the vessel from wreck and injury under trying circumstances, a lower cost of insurance, smaller bills of expense generally, and fewer losses to the owners. The energy and daring of the excellent crews of that period were the admiration of the maritime world, and gifts of plate, the freedom of the city, and other testimonials to their merit were not uncommon. The temperance that prevailed on American vessels was the subject of comment in a report to the British parliament in 1838.

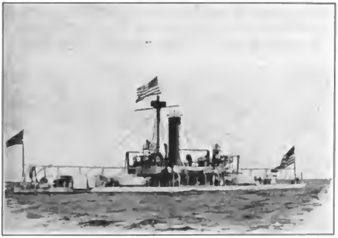
English steamers were sent out in 1838 and 1840 to compete with these packet lines. The Cunard Line began in 1840, backed by a subsidy of £90,000 a year, afterward increased to £145,000. The Americans responded in 1847 with a line of steamers to Bremen, and in 1850 with the Collins Line to Liverpool.

Then began the era of steam navigation of the Atlantic; but the steamers at first did not display speed. Under ordinary circumstances their trips across the Atlantic were made only in good average sailing-packet time. Nor did they have great carrying power, as their capacity was occupied with coal and machinery; but they enjoyed the advantage of being able to pursue their course in storms, and in 20 years they had gained so much in speed and carrying power, and were so heavily backed with subsidies that sailing ships could no longer compete with them.

The United States aided the revolution from sail to steam just enough to destroy completely her splendid packet lines to Europe without replacing them by steamships carrying her own flag. In 1857 all the subsidies to steamers to Europe were withdrawn by Congress, and, in consequence, the Collins and the Bremen lines were taken off. The sailing packets had meanwhile been entirely superseded and from that day to the outbreak of the present war the passenger, mail, and express traffic of the Atlantic has been transacted almost wholly in European-built steamships. Sailing packets had disappeared even before the war of 1861, which gave the final crushing blow to the hopes of early American supremacy of the sea.

THE CLIPPER SHIP

The shipbuilder's art in America had by this time arrived at a state of excellence never before attained in the world, and ship-owning had reached the most flourishing stage in its history. The large transatlantic packet ships had already become established, stimulated by the Irish famine and the beginning of transatlantic travel, and it was just about this time that the great clipper ship began its career, due to the growth of various branches of trade in which speed was as important for commercial purposes as it was for passenger travel.


U. S. MONITOR "TERROR"

In 1848 an event occurred which gave a great stimulus to the demand for clipper ships. Gold was discovered in California; and as that region was practically as far away as Asia, no vessels could be sent there except those that were large and staunch. A few vessels had found their way to San Francisco before that territory had been purchased, and a number soon afterward. Parcels of gold sent East by the Isthmus of Panama created a rush of emigration and trade wholly unparalleled in the history of the New World for its sudden rise and great magnitude, and a great part of the freighting tonnage of the Eastern States was called on at once to engage in voyages to and from the Isthmus of Panama on both sides of the continent, and also in trips to San Francisco around Cape Horn. By 1850, such was the rush, that 150 to 200 vessels were sometimes at anchor in the Bay of San Francisco, where five years before it had been rare to see half a dozen. These were nearly all American vessels, as under our laws none but American ships could bring cargoes from the Atlantic Coast. A few packet ships were turned into this new and profitable trade, but the majority were freighting vessels of large size. The time spent in making the run between New York or Boston and the Pacific Coast was from 120 to 150 days; but in the summer of 1850 two small tea ships arrived from New York in 100 days. This quick passage caused the merchants of the West to realize the advantage of fast ships, and Alfred Peabody, of Salem, Mass., and J. P. Flint, of Boston, who were on the coast, at once resolved to build clipper ships for the trade.

All these influences combined made the period from 1848 to 1857 one of the greatest excitement and activity in shipbuilding in the United States. The years 1851, 1852, and 1853 were noted for the fine ships produced, and 1854, 1855, and 1856 had never been equaled in the United States, either for the amount of sailing tonnage built or for the gigantic size and great beauty of the large vessels, and no other age had seen so noble a sailing fleet as that which sprang into existence from the ship-yards of Baltimore, Philadelphia, New York, and Boston in those years of unwonted excitement and prosperity.

CLIPPER SHIP "MORNING LIGHT"

The era of sharp ships was now fairly inaugurated, and many of this class were built not only at New York, but at Boston, Philadelphia, and Baltimore. Nearly all the early ones did not exceed 1,000 tons register, but competition and expanding trade led to a great increase in size, and every year saw vessels launched spreading more and more canvas, longer, larger, and faster than ever, and expressly intended to beat everything that had gone before them in the merchant shipping of the world. In ten years after the first clipper the size of 2,400 tons was reached, and there were large numbers built of about 2,000 tons. The exploits of the new ships were amazing, and created the greatest excitement in shipping circles; in fact, they effected a remarkable revolution in the sailing tonnage of the world.

The clippers first built had sharp floors and sailed with a drag. Some of them from Baltimore drew 16 feet aft and only 8 feet forward, the midship section or broadest part of the hull, being at two-fifths the length from the bow, as in the packets and heavy freighting ships. The forward body was full and the after body lean and tapering under water. This was gradually changed in imitation of the fast yachts and pilot boats of New York City, and after 1851 the long, sharp bow was considered the best for speed. The midship section was moved back in a few vessels to the center of length, and the after body was made fuller and more powerful. The ship was then made to sail on an even keel. The bottom was also made fuller. About 1854 clippers began to be built with full bottoms, retaining the long bow, hollow water-lines, and other peculiarities of the swift model. These were good ships, and the form thus attained has ever since been popular in fast ships.

The speed of clippers was remarkable. They ran across the Atlantic to Liverpool at an average speed of 9 miles an hour, spurting at the rate of from 10 to 13 miles with the right wind, and on voyages that gave them the advantage of the trade winds they ran for days and weeks in succession at an average speed of from 12 to 15 miles an hour. To sail 300 miles a day was not exceptional. The Red Jacket made 325 miles a day for a week; the Flying Cloud once sailed 427½ miles in 24 hours; the James Baines, an Australian packet, built by McKay at Boston, once sailed 420 miles in 24 hours; and the Sovereign of the Seas, it is said, while on a voyage from the Sandwich Islands to New York lasting only 82 days, made 437 miles in 24 hours.

A great many approved appliances were invented for use on the clipper ships, among them the idea of double topsails. Captain R. B. Forbes, of Boston, was the first to divide the enormously large and high old-fashioned topsail and make the lower topsails yard stationary at the cap of the lower mast-head. He made the mast-heads long, to suit the rig. The upper topsail yard kept the place occupied by the original yard, and was raised and lowered in the same manner.

THE MASTER BUILDER

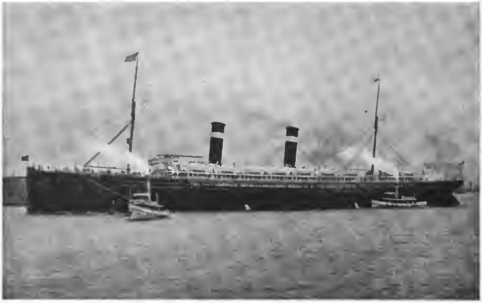
The term "merchant princes" as applied to the owners of these vessels was quite apropos—they were fully conscious of the importance that the name conveyed and they asserted it on all occasions.

The captains of these ships assumed a dignity and pompous manner which marked them as the most important habitués of the maritime districts of the great commercial cities on the Atlantic coast, and their preeminence over the rest of mankind was never questioned there. They were a handsome set of men, and when in port were well dressed, and often pretentious as well as dictatorial in their speech and conduct.

There was one person, however, who, while looking on these two parties with amiable and condescending spirit as to the usefulness and necessity of their existence, firmly believed that he and his occupation were of paramount importance; he not only felt and looked it, but he was the "master builder" in reality.

The preëminence of the master builder had prevailed in the Levant from the very earliest times. The war galleys of the ancient were a principal factor in the development and continued existence of their power, and the maker of the galleys naturally became a person of commanding influence. An idea of his standing can be had from the fact that special laws were enacted in his behalf—he could be arrested only by a captain of cavalry and one hundred men. His peremptory and dictatorial manner was due to the fact that he not only knew more than any one else as to his profession, but that he was supremely conscious of it. That he was born to his art was indispensable, for no purely theoretical education can make a great shipbuilder.

The acquisition of great wealth never appealed to him, and no master builder was ever known to have accumulated a fortune (from shipbuilding alone); to excel in his profession and to enjoy the pleasurable consciousness of having performed a great work was the prevailing idea that dominated his mind.



AMERICAN LINE S. S. "ST. PAUL"

Mr. William H. Webb, the most noted of the earlier American shipbuilders, accumulated a fortune as a ship owner, but not as a shipbuilder. He was connected with most of the steamship lines that had their origin in the demands of trade consequent upon the discovery of gold in California. The most noted ship in that trade was the Golden Gate, built by him at that time.

Certain New England builders acquired ownership in some of the ships they turned out, with a fair success in a pecuniary sense. These cases cannot be considered exceptions to the rule or to any statement that no master builder ever acquired a fortune in the pursuance of his profession.

Among the great shipbuilders or master builders who were to be found in New York at this time were the Webbs, the Westerveldts, the Steers family, J. Simonson, Bell & Brown, Smith & Dimon, and many others besides; in Philadelphia, while the output was not so great nor the vessels so large, there were to be found John Vaughn, John Birely, William Cramp, Matthew Vauduzen, John K. Hammet, and many others. Most of these shipbuilders neglected to familiarize themselves with the application of the steam engine to ship construction even in the most general way, and this resulted in a gradual elimination of the cult or guilds of the master builder that had existed for centuries. In passing, it may be stated that prior to 1900 no American shipbuilder enjoyed an international reputation in any degree approaching that of Mr. Charles H. Cramp. He was the real representative of American shipbuilding in the eyes of the European shipbuilding world.

At an early period shipbuilding in Philadelphia was included in a triangle of Kensington, bounded by Frankford Road, the Delaware River, and Montgomery Ave. It included the site of the old Treaty Tree, and had been occupied by the master builder, shipwright, ship joiner, ship caulker, ship smith, mariner, ship owner, and others pertaining to the profession, from Colonial times. While other pursuits had crept into this triangle, these were the prevailing ones.

The shipwright in Philadelphia emulated the master builder in his peculiarities; while not so picturesque, the shipwright was just as exclusive, as proud and self-conscious as his superior, the master builder. They were both typical Philadelphians, when it came to pride in occupation, their views as to its social status, and the value of pedigree. But the master builder himself regarded his occupation as far above all others.

The shipwrights and their associates, in the pride of their occupations, held themselves aloof from all others; they drew the line at all occupations outside of or not connected with their cult, and if a daughter married outside of the line she was promptly placed under the ban of social ostracism.

The pride and peculiarities of these people were indicated in many ways. All shipwrights wore white shirts while at work, and in warm weather they put a clean one on every day. A woman soon lost caste if she permitted her husband to go to work two consecutive days in the same shirt. They took particular pride in the cleanliness and clothing of their children, particularly in regard to school attendance, and they never sent them to the public schools until the grammar school and high school were established, as six months' attendance at grammar school was necessary to enter high school.

EARLY SHIPBUILDING IN PHILADELPHIA AND NEW YORK

Long before the Revolution Philadelphia was known for what Gordon calls the "noble manufacture of ships," where both before and after the Revolution shipbuilding was extensively carried on, and it is known that the city produced the finest craft in the New World; certainly many famous war vessels and large trading ships were built.

After 1814 building went ahead strong in New York and the fashions were thereafter set by builders on the East River. These vessels and the river steamboats, which were then coming into prominence, gave work to a long row of shipyards extending from Pike Street, along the East River front of the city, for a mile and a half.

William H. Webb, the great builder of packets and clippers at New York, and afterward of wooden steam vessels, built more tonnage on foreign account than any other builder at this port (138 vessels). One of his ships was the Ocean Monarch, of 2,145 tons, and another the great iron-clad steam ram Dunderberg, considered in her day the most formidable fighting ship in the world.

Philadelphia had a large East India trade, her shipyards were numerous, and the talent employed in them was good. Of all the many yards engaged in wooden shipbuilding but one remains, and that the world-famed yard of William Cramp & Sons. Mr. Cramp, in speaking of the history of the company, which achieved so much under his direction, states of the transition from sails to steam and from wood to iron as follows:

> "We witnessed the very beginning, appreciated its importance, and were convinced of the impending and inevitable revolution in the art: we therefore prepared ourselves by securing all the information accessible here and elsewhere both as to the use of iron and the use of steam. We began the construction of iron vessels in a comparatively small way during the Civil War, and our yard became a sort of kindergarten, as most of the workmen had to be trained to the work and working appliances had to be designed. Most of the members of the old firm could take any part of the building of a ship from mould loft to launching; and they soon were able to take any part of iron work from bending frames to bending plates and designing furnaces and other appliances. We soon found that practically new men would have to be utilized, as the boiler makers, mostly foreigners, who worked at the business were few in number, and did not grasp the mechanical necessities of the new departure.
>
> "Many young ship carpenters and joiners and some fishermen, all natives of this place, in order to secure themselves against probable changes took up all varieties of work except riveting, which they did not consider a mechanical occupation. With their mechanical instincts and perhaps superior education and training they soon outclassed the old stager, and all of this work up to the present time has been done by these men.
>
> "Most of the foremen, leaders and best men from drawing room to riveters, in all of the new shipyards have come from our place, and in that respect they might be considered branches of the old firm."

Mr. Cramp spoke truly in likening the Cramp Yard to a kindergarten, for from that yard came the men who became factors in the establishment and development of nearly all the shipyards of the United States, before the beginning of the present struggle for freedom of the nations from German-imposed "Kultur," and who are now making the world's history in the number of vessels constructed and methods of fabrication. In this connection tribute must be paid to the late Mr. Morse, of the New York Ship Yard, who had the vision, the courage and tenacity of purpose to establish the Camden Yard, with the avowed purpose of applying the methods of bridge builders to shipbuilding.

STEAM VESSELS

The screw was adopted for towing at Philadelphia in 1849. Some one in that city who had two towing boats of the old paddle-wheel type saw the advantage of propeller tugs for harbor and canal use when he saw the Robert F. Stockton towing four coal barges at the rate of a mile in 11 minutes. The first propeller tugboat built on the Delaware was constructed by William Cramp, of Philadelphia, and was fitted with engines made by Jacob Neafie. She had a wooden hull 80 feet long, 17 feet broad and 8 feet deep. This boat did excellent service on the Delaware, and her success brought a great deal of business to her enterprising builders. It was thought at first that the entire screw should be below the hull of the vessel, in order to exert its full power; but Mr. Cramp departed from that idea and fitted the Sampson with a 6-foot wheel, only half of which was below the hull, and with a 3-foot keel to protect the screw. After a number of boats had been built of that style some one wanted a light-draught tug, and the board keel was then removed and the wheel entirely above the bottom of the vessel. This boat proving to be as efficient as its predecessors and much more handy, a revolution was effected in the form of tugs.

The screw propeller made its first appearance in the coasting trade at New York in 1841, the Clarion, of about 250 tons, being built in that year for service between New York and Havana. This vessel was the pioneer of the present splendid fleet of screw-steamers in the coasting trade, and was driven by a 6⅓-foot Ericsson wheel. Philadelphia quickly followed the example of New York, and, in fact, was much more energetic in adopting screw propulsion. In 1842 six screw-steamers were built at Philadelphia, two of 80 tons each for trading to Baltimore and four of 200 tons each to run to Albany and Hartford, with 6½ and 6-foot wheels, respectively, all of the Ericsson patent. Other vessels of the same class followed from time to time.

The Ericsson patent was in the ascendency in the earlier years; but engineers were never quite satisfied with it. Woodcroft, in England, and following him, various American inventors, including Loper, at Philadelphia, had experimented with screws based on the principle of an expanding pitch. In the original propeller the blades were set at right angles to the axis, and had the twist of the real Archimedean screw, while in the Woodcroft and later propellers the blades took somewhat the form of the three- and four-leaved clover, and had a second twist in them, the pitch expanding from the axis to the periphery. The blade has become elongated in the course of the experiments of the last twenty years, and its form has changed somewhat. The present practice requires an heliocoidal surface.

SUBSIDIZED AMERICAN MAIL SHIPS

Several companies were formed in New England for transatlantic trade, but the plans of Samuel Cunard were the first that received the approval of the Government. Cunard built four paddle-wheel steamers of about 1,140 tons each, and he was authorized to carry the mails to Halifax and Boston for a yearly compensation of £80,000. In a few years the line was extended to New York with a yearly compensation of $725,000, afterward increased to $865,000 a year. The plans of Cunard were carried out in such a manner that they met the expectations of the owners of the line and of the English Government perfectly, and seldom has a grand commercial scheme been crowned with such triumphant success.

Under the laws of 1845 a contract was accordingly made by the United States with Mr. Collins, whereby he was to build and run four steam vessels from New York to Liverpool, making twenty trips per annum, and carrying mails for $385,000 annual compensation. The ships were to be of 2,000 tons register, of the most powerful character, and suitable for men-of-war in case of need. The Cunarders were then of 1,140 to 1,500 tons register. Mr. Collins was resolved upon unquestioned excellence, and he forthwith prepared to build four ships of 2,800 tons register each, of the best materials and workmanship, and fitted with machinery of unusual power. The Arctic, of 2,856 tons, the clipper of the fleet, and the Atlantic, of 2,845 tons, were built for him in 1849 by William H. Brown, at New York, under the superintendence of George Steers, a famous builder. The Baltic, of 2,723 tons, and the Pacific, of 2,707 tons, were built by Brown and Bell, of New York. The machinery of these vessels was supplied by the Novelty and Allairo works, of New York City.

In selecting a model for his fleet, Mr. Collins chose some of the peculiarities of the modern swift propellers. He adopted a straight, though slightly raking stem, a long, sharp, wedge-like bow, and a long easy run. The floor was full, but with easy lines everywhere. The hulls were carried up out of the water high enough to inclose the houses and cabins, and gigantic four-deck structures were produced, with a full complement of masts and spars, that loomed up long and large above every other ship in the port of New York, and won the unqualified admiration of all who saw them.

PANORAMA CRAMP'S SHIPYARD IN 1906

The best talent of the day was consulted with regard to every point about the hulls and machinery of these four noble vessels, and in every detail they were of excellent design and workmanship and in appearance imposing. Service began with these ships in 1851.

The Cunard steamers were making the voyage from New York to Liverpool in from 10 days 6 hours, to 14 days 3 hours, averaging in the year 11½ days. From Liverpool to New York their time varied from 10 days 2 hours to 16 days 20 hours, averaging 12 days 9 hours. The Collins vessels beat this time from the start by an average of about 1 day, their voyages to Liverpool being made in from 9 days 17 hours to 12 days 9 hours, an average in a year of 10 days 21 hours; the return trip was accomplished in from 9 days 13 hours to 13 days 17 hours, the average being 11 days 3 hours. The ships had the confidence of the public, and were liberally patronized. From January to November, 1852, inclusive, for instance, they carried 4,306 passengers, as against 2,969 who went by the Cunarders. Their competition for freights brought the rates to Liverpool down from £8, 10s. to £4: a great public benefit, because the United States was importing enormous quantities of European manufactures and paying the freight to this country. The voyage to Europe was shortened by these ships and travel was promoted and in eight years from the time they began, the passenger traffic increased fivefold.

The Cunard Line began to build new and large steamers the moment the Collins Line was undertaken. Collins' mail pay was increased to $858,000 a year, and great speed was required of him. He fulfilled the requirements, and the company that backed him spent large sums of money in perfecting their engines and machinery and maintaining their boats in full efficiency. In 1854 the Arctic was lost at sea by a collision in a fog with the French steamer Vesta, only 45 out of the 368 people on board ever reaching land. The Pacific was lost in 1856 with all on board, numbering 186 persons, and a valuable cargo. The ship, with her contents, was insured for that trip for $2,000,000, and nothing was ever heard of her after leaving Liverpool in January, 1856. Neither was built with bulkheads.

Collins acted with energy in replacing the Arctic. In 1855 he built the colossal Adriatic, of 4,144 tons register, 345 feet long, 50-foot beam, and 33-foot hold, at a cost of $1,100,000. The ship cost more than was expected, owing to alterations in her machinery and her long detention in port while the changes were being made; but she was a good vessel, fast and capacious, and once in 1861 made a trip from Saint Johns to Galway in the unprecedented time of 5 days 19¾ hours.

Beginning in 1853, a movement had sprung into existence for cancelling Collins' subsidy. This agitation went on, until 1856 the pay of Collins was reduced to $385,000 a year, and in 1857 it was withdrawn altogether by the refusal of the Government to renew the contract.

IRON VESSELS

There is no record of the building of an iron vessel in the United States until 1838, when the little light draught steamboat Cadorus was launched in Pennsylvania, for service on the Susquehanna River. This was only four years after the advent of the first iron steamboat in England. The boat was employed on the Susquehanna River for a while, and was then sent south for river service there.

Mr. Cramp states that, "The first iron boat built in the United States, about 1838, was the barge called the Cadorus, and soon after another was built by Jesse Starr, in old Kensington, several squares from the river, near old Marlborough and Franklin Streets (Girard Avenue). I saw it as a boy, when it was hauled down to the river by a large team of horses from the boiler works, where built.

"A barge built of iron by boilermakers and hauled through the streets of old Kensington, the citadel of the shipbuilding, was an event of great wonder and importance. It attracted great crowds witnessing the transportation to the water, and was an endless subject of discussion at that place."

Several small vessels were built afterward by engine builders and boilermakers, it being practically conceded as plates were to be bent and riveted, and as the iron vessel was a type of steam boiler, that none but boilermakers were expected to build them; and they continue to do so practically up to the present time.

As early as 1842 Philadelphia had produced a line of small iron steamboats to trade to Hartford, Conn. That year was, relatively, a favorable one for the rise of an iron shipbuilding industry in the United States, for iron had just touched the lowest prices ever known on this side of the Atlantic.

While iron ranged low, a number of boats, all of moderate size, were built in New York and Philadelphia, and a now famous yard at Wilmington, Delaware; the most work appears to have been done in New York, the industry being fostered in that city by the great marine-engine shops, four iron revenue cutters being built there in 1843 and a number of small merchant steamers about the same time.

SHIPBUILDING DURING THE CIVIL WAR

After the war of 1861 had broken out the value of every form of cast and rolled iron sprang up in a remarkable manner. In 1864 pig metal had touched $73.50 per ton, the highest figure in the history of the United States, and the average of that extraordinary year was $59.25, something entirely unprecedented. Wages also rose to the highest point ever known, for the army drew off an immense number of workmen. Other circumstances remaining as they were before the war, these events would have closed the gates of every iron shipyard in America; but the period was exceptional, and those four years were, in fact, years of intense activity in all the yards. It was necessary to construct a large number of iron-clad war vessels immediately, and in the emergency the reliance of the Government was almost wholly upon private shipyards. Foreseeing that this would be the case, the proprietors of Boston, New York, Philadelphia, and Wilmington fitted up their yards in anticipation, putting in expensive machinery for the bending of iron frames and plates, the punching and rivet holes, and the forging and handling of iron bars and shafts. The contracts which they afterward received enabled them to go on and improve their plant, and several firms invested from $250,000 to $1,000,000 each in shops and machinery of the most massive description. The liberal expenditures for armored vessels and monitors during the war gave the iron shipbuilding interest the most powerful impetus it has ever received.

This result has since proved of immense value to that part of the commercial community which is compelled to own and employ steam vessels in deep-sea trade, and has firmly established the art in the United States, improved the quality, and decreased the cost of American iron-built ships.

In 1861 William H. Webb built the iron-clad steam-propelled frigates Re d'Italia and Re Don Luigi de Portugallo for the Italian Government. The contract for them had been entered into before 1861, and some trouble was experienced in completing them, but the work was finally accomplished, and the ships were sent across the ocean and delivered. The Re d'Italia was 282¼ feet long on the upper deck from the after side of the rudder post to the forward edge of the hawser pipes. The breadth of beam on the load line was 54 feet, and the total depth of hold 33½ feet. The Re Don Luigi de Portugallo was 3 feet shorter. The armor of these vessels was mounted on a frame of oak and locust of the most massive description, and the weight of each ship with everything on board, including armament, was 6,150 tons. Each was capable of speed of from 15 to 17 knots per hour. The Re d'Italia made 14 knots per hour on her first trip, with steam up in only four of her six boilers.

A monster iron-clad was soon afterward built by Webb and sold to the French Government. Originally ordered by Secretary Welles for the United States service, she was not completed until the war was over. Her builder then obtained permission to sell her abroad, and she was sold to France. This ship was called the Dunderberg, but was rechristened the Rochambeau after her sale. She was a long and powerful ram, laying low in the water, but with a high shot-proof casement amidships for the working of the guns. The extreme length was 380 feet, the beam of the hull on the plank-sheer 59½ feet, the beam over-all above 72⅝ feet, and the depth of hold amidships 22⅚ feet, with a casemate 7¾ feet high inside superimposed. The portion of the bow which formed the ram was 50 feet in length. Mr. Webb gave this ship an almost perfectly flat floor, so as to gain the largest possible displacement. The dead rise was only 4 inches. The hull was massively built of wood with armor above of 4½-inch iron. The frames were spaced 3 feet apart and molded over the keel 17 inches, at the floor heads 14 inches, above the bilge 13 inches, and at the plank-sheer 9 inches. The sides of the casemate were 3 feet thick, and were set at a slope of 35° to compel the glancing of shot. A thousand tons of iron were used in the armor, and the displacement was about 6,900 tons. This weight was carried on 21 feet draught. The ship engines (two in number), were built by John Roach & Son, and developed 5,000 horsepower, giving a speed of 15¾ miles per hour. This ship registered 5,090 tons, and was the fastest armed steamer in the world at that time.

Another instance of the enterprise of private builders during the Civil War period is found in the construction of the vessel known as the Stevens Battery. This vessel was designed, financed, and partially completed by the celebrated American engineer, John Stevens, with the idea of presenting it to the U. S. Government on behalf of the State of New Jersey. The war ended, however, before the completion of the vessel.

It was remarkable in that many of the present-day features of war vessels were included in the original design. The battery was of the all-gun type, that is the guns all of the one calibre, with bow, stern and broadside fire. The arrangement of the machinery was for twin screws. The armor was worked with inclined sides and the rudder was of the balanced type, almost identical with the afterwards celebrated Biles-Thomson type. After the war, the State of New Jersey, to which the vessel was willed by Mr. Stevens, attempted to finish it, and Gen. Geo. B. McClellan was put in charge of the construction. Many changes were made in the original design, and finally the cost becoming so great the project was abandoned, and the vessel broken up.

Philadelphia, from its nearness to the iron and coal mines and from the remarkable development of the iron-manufacturing industry in the towns lying back of and around her, has always enjoyed a great advantage in iron-ship building. The city had a large number of engine-building works, and was exceptional in the cheapness of her iron, and coal. It was natural that she should take a lead in iron-ship building the moment the industry had reached a point where the price of material and convenience of access to rolling mills nearby should begin to tell.

It has already been noted that the first iron vessel in America was a light-draught river boat, which was launched in 1838 for use upon the Susquehanna. In the thirty years following 1825 quite a number of small iron vessels were built in the city—steamboats, revenue cutters, etc., I. P. Morris, James T. Sutton & Co., and Neafie and Levy building from time to time, the hulls being designed and laid down on the mold loft floor by practical ship carpenters. It does not appear, however, that the product of the industry was so large and important as that at New York until after the beginning of the war of 1861.

The outbreak of hostilities was, however, a signal for preparations in Philadelphia for large ships. William Cramp fitted up at once his wooden shipyard (where, since 1830, he had built 106 vessels) with machinery for the handling of iron plates and frames. His first vessel was the United States man-of-war New Ironsides, of 3,000 tons, 230 feet long and 56 feet beam, which was a strong wooden ship, iron clad above the water. She was built before the yard had been fully fitted up with machinery, and the armor plates were purchased from another concern. When the contract was made the timber for her frame was still growing in the woods; yet in six months' time she was launched and on her way to Charleston. Mr. Cramp afterward built the monitor Yazoo, the steamer Chattanooga, and a number of transports, and did a large amount of other government work.

Meanwhile he was steadily improving the plant of the yard, and after the war it became one of the great shipbuilding concerns of the United States.

THE CRAMP AND MERCHANT SHIPBUILDING YARDS AFTER THE CLOSE OF THE CIVIL WAR

The needs of the coasting trade were carefully considered, and a number of small iron steamers and tugs were built at the yard. Two steamships were built for the Clyde Line, and then in 1872 Mr. Cramp obtained the contract to build four steamers for the new American Line to Liverpool, of 3,016 tons each, at a total cost of $2,400,000. These boats made the reputation of the yard, and there being then no American steamers in the trade from the United States to Europe, it was deemed important to construct them in good style as specimens of American workmanship. They were modeled long and narrow, with fine bows and runs and slightly hollow waterlines. The dimensions of each were: Length over all, 355 feet; breadth of beam, 43 feet; depth of hold, 35 feet. Decks, 3 in number; 2

masts. Each ship was supplied with two compound 1800-horsepower engines, with 57 to 90-inch cylinders, having 4-foot stroke, and a 16-foot wheel. The ships were completed in 1873, and proved fast, smart, and strong vessels; their speed was 13 miles an hour. As passenger boats they fully answered all expectations; their average time from Cape Henlopen to Queenstown was 9½ days, and on the return 10 days 2 hours. Each carried 100 cabin and 800 steerage passengers, 1,740 tons of cargo, and 720 tons of coal on 20½ feet draught of water. The export trade to Europe now requires steamers of immense size and capacity with great speed, but in the day when they were built, the American boats did all that was demanded of them.

In 1872 Mr. Roach bought a large property at Chester, formerly the property of Reaney, Son & Archbold, and developed there a great iron shipyard, his first vessel being launched in 1873. It was always a busy yard, producing regularly not less than four and sometimes as many as ten large class steamers a year, and is still busy in the hands of the Merchant Shipbuilding Company.

The success of this yard, like that of William Cramp & Sons, has been due to qualities on the part of its founder which have characterized the leading shipbuilders of America in a marked degree—energy, fertile minds, and remarkable ingenuity in adapting vessels to the trade in which they were to be employed. A special study would be made of the kinds of cargoes carried by the vessels in a particular coasting route, and an idea would be formed of a ship which would carry more of the given varieties of goods on a lighter draught of water, and at a faster rate of speed than the vessels already in the trade. This idea would be worked out in a ship, in which the builder would take perhaps a quarter interest, in order to show his confidence in it.

The vessels built at Chester include many of note. The City of Pekin and the City of Tokio ran for a long time from San Francisco to China, and were large carriers of cargo and small burners of coal. The Para and the Rio de Janeiro were the builder's own venture in the way of a line of steamships to Brazil, in which trade they ran for three years, being then withdrawn and sold to the Pacific Mail Company. All of the coasting steamers have long, sharp wedge-like bows, good runs, and easy lines, and have been remarkable for their speed, light draught, and cargo-carrying power.

CONCLUSION

We have thus before us a vivid statement of the early history of shipbuilding of this country, and one that represents the struggles, financial and otherwise, which enabled the master builders to hold on under the most adverse circumstances, with no encouragement from National legislation, until the rehabilitation of the U. S. Navy in 1882 gave such impetus to the industry as to enable shipyards to develop and train men who are to-day guiding the monster shipbuilding industry of the country. It took all the needs of a world war to awaken the United States to the importance of an industry it had allowed to languish and almost decay, while other nations were forging ahead with the stimulus of National aid and encouragement.

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U. S. S. "PENNSYLVANIA" LEADING THE ATLANTIC SQUADRON

ELECTRIC WELDING AS APPLIED TO STEEL SHIP CONSTRUCTION

A series of discussions held under the auspices of the Electric Welding Branch of the Education and Training Section of the U. S. Shipping Board. Emergency Fleet Corporation.

Third Discussion.

TIME SAVING IN STEEL SHIP CONSTRUCTION*

By J. H. ANDERTON
Electrical Engineer, American International Shipbuilding Corporation

THERE are a number of features involved in the application of welding to ship construction which do not ordinarily apply to the usual and normal fields of welding. In the locomotive shops the personnel directly concerned is the master mechanic, chief engineer and similar officials, who among themselves decide as to the usefulness and general applicability of welding. Mistakes are rectified as the work proceeds and find new application. The same thing takes place in a large number of munition shops where bombs, grenades and similar munitions are being successfully welded in very large quantities.

The Interests Affecting the Application of Electric Welding to Shipbuilding.

These features, however, are not so simple when applied to the present-day ship program. Practically all ships being constructed in the United States at the present time are directly or indirectly under the control of our Government, and the interests affecting the application of welding to the vessel in any of its parts may be put as follows:

1. The personal interest of the Yard constructing the vessel to see that all parts are securely and properly put together, to the end that the vessel shall finally reflect full credit to its constructor. This is identical with the interest of the railways, manufacturers and others.
2. The interest of the representative of the United States Shipping Board as representing the Owner, to the end that the Owner shall receive a good ship.
3. The interest of Lloyds Register of Shipping and the American Bureau of Shipping, which are identical.

Lloyds Register and the American Bureau of Shipping have jointly issued a circular letter embracing a certain number of parts in the vessel where electric welding will be approved. It is expected that this list of items will be added to as recommendations are made by the various shipyards and other welding interests, dependent upon the judgment of the Classification Societies as to their safety. There are hundreds of places in the vessels which have not been specifically embraced in the list published by the Classification Societies, but which, however, can be assumed as embraced in this approved list.

When the welding engineer in any shipyard decides that he sees some particular operation in the construction of a vessel which could be more suitably performed by welding than by the usual methods, the following procedure is necessary:

1. The approval must be obtained of the structural engineer or other official having jurisdiction over such matters in general at the Yard concerned.
2. Note must be made to see if this operation has been embraced in the Classification Societies' list. If examination discloses that it has not been embraced, it is necessary to take this up as a specific item to be passed upon by both societies.
3. It is necessary to take this item up, in most cases, with the authorized representative of the U. S. Shipping Board for his judgment and approval.

The writer personally feels that this method of procedure is at the present time one of the greatest obstacles to the application of electric welding on the present ship program, for the difficulty and time consumed on obtaining approval upon each specific item in the manner above outlined is disheartening and tends to prevent the automatic operation of methods which have proven satisfactory in a large number of cases.

Shipbuilders, however, have been proceeding along established lines of practice for a great number of years; this practice has proven itself satisfactory and it is to be expected that a great amount of caution will be exercised on their part in the substitution of any method for an established and satisfactory system.

SPOT WELDING

While spot welding is embraced in these discussions of the application of welding to ships, no spot-welded parts of steel ships have yet been specifically approved by the Classification Societies. One reason for this may be found in the fact that up to recently large spot-welding machines were not very generally in use in this country. There are, however, a number of machines now in the process of manufacture, and it is expected that as experiments proceed with the actual machines it will be demonstrated to all parties interested that spot welding can supersede riveting, particularly in the fabrication shops, to a very large extent.

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* Delivered in the Auditorium of the Engineers' Club, July 17, 1918.

There are at the present time a large number of places in vessels where spot welding can be applied without the necessity of consulting the Classification Societies, viz.: the portion of the construction members of the vessel which are not capital parts of the ship. Such items as crow's nests, smoke stacks, uptakes, ventilators, cowls and stacks, interial ventilation ducts, skylight framings, stair treads and stringers, certain watertight and non-watertight bulkheads; and in fact a large amount of this work is already being spot welded, particularly the parts of fabricated skylights. Experiments have also been made with spot welding of watertight doors, and this is permissible under the definite restrictions of the Classification Societies. The time saved by the full application of spot welding in all its possibilities to the parts alone, not particularly effected by the Classification Societies, is enormous.

THIRTEEN-FOOT MAST ELECTRICALLY WELDED

POINTS EFFECTING TIME SAVING

The four fundamental points which effect time saving by welding in ship construction are: First, an intimate knowledge of and a proper attitude towards the application of welding by the designing forces in the drafting room; second, welding equipment in the shops and its flexibility as applied to the work; third, welding equipment and distribution system on the ways for the vessels themselves; and, lastly, good welds and good welders.

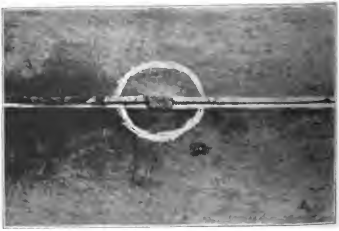
THE ATTITUDE OF THE DRAFTING ROOM

In discussing the various items, where welding can be applied on vessels, with the designing forces, particularly the men in what is called "Hull Findings," the writer has been agreeably surprised to note that these men are actually anxious to find out all that is known about welding. Looking at it from their point of view it means, practically speaking, the entire absence of careful dimensions for punching or drilling and has substituted therefor something which is placed in its proper position and stuck there. The future of electric welding as applied to ships, will in the writer's opinion, be determined largely by the attitude and general information and knowledge which the designers are able to obtain in connection with welding.

Any one will recognize that it is a much simpler method in making up details for vessel construction and fittings to show any specific item located on an assembly drawing with no necessity for detailing the drilling or punching to be carried out in the shops, when it is considered that in an ordinary vessel there may be from 500 to 5000 of these items on which detailed drilling or punching could be eliminated, and the items shown on the assembly drawing with a note "Weld" attached thereto or the proper standard symbol shown. The item of time saving in this branch alone is considerable. The same remarks, of course, will apply to all detail drawings which are prepared for the fabrication work in the shops. The entire elimination of the detailing, and the substitution therefor of the "Weld" or its equivalent, would effect the same result in time saving.

FLEXIBILITY OF EQUIPMENT

On the assumption that the designing engineers are properly acquainted with the flexibility and value of welding in their work, the next step is to have on hand the proper equipment to carry out the work both at the shops and at the ships. The design of a proper layout and the purchase of equipment for use both at the ships and in

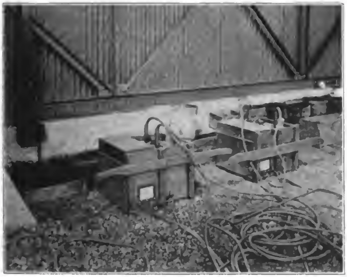

ENLARGED VIEW OF SPOT WELD ON THIRTEEN-FOOT MAST

the shops is in most cases dependent upon the local conditions of the Yard affected. Hog Island Yard has been more or less fortunate in this respect, since the plant is new and had not progressed in construction to a point beyond which it could not be changed or modified to suit the conditions required by electric welding. Since local conditions will, in nearly all cases, govern the layout of a shipyard, perhaps the best thing to say about that would be to describe the system at Hog Island.

The general system at Hog Island is served by two 66,000-volt, 60-cycle, 3-phase transmission lines terminating in a central sub-station of approximately 30,000 KVA. capacity. Three-phase feeders are carried from this sub-station for lighting and power on the 3-phase, 4-wire system with 4150 volts between phases. This permits the use of standard 2300-volt apparatus while retaining the advantages of the 4150-volt distributing system.

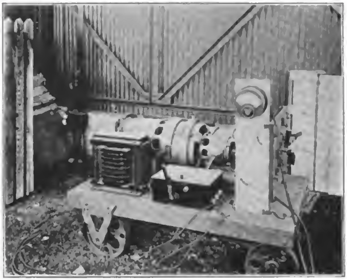
In connection with the shops, these are located approximately three-quarters of a mile from the main substation. The group occupies a space approximately 1500 x 800 feet; a small sub-station is located near the center of the group. Power is stepped down from 4150 volts, 3 phase to 440 volts, 3 phase. At this voltage it is used for all types of motors in the shops, cranes and one special case of direct-current motor generators for use with jib cranes. For welding, 440-volt power is distributed to central cabinets located at convenient intervals on the walls of the shop. These cabinets contain fuses for usually about six or seven circuits. From these cabinets conduits are laid underground to various places in the shop and terminate in a 440-volt plug outlet. These outlets are located at sufficient intervals so that portable welders may be attached at any convenient place near the work.

In the Plate and Angle Correction shop there is in course of erection a very elaborate training center for welders. This center was installed under the auspices of the Fleet Corporation and is capable of training 42 welders simultaneously. It is expected to use this center not only for training welders but as a production point where repetition work can be advantageously carried out.



ONE-MAN PORTABLE D. C. ARC WELDING OUTFIT

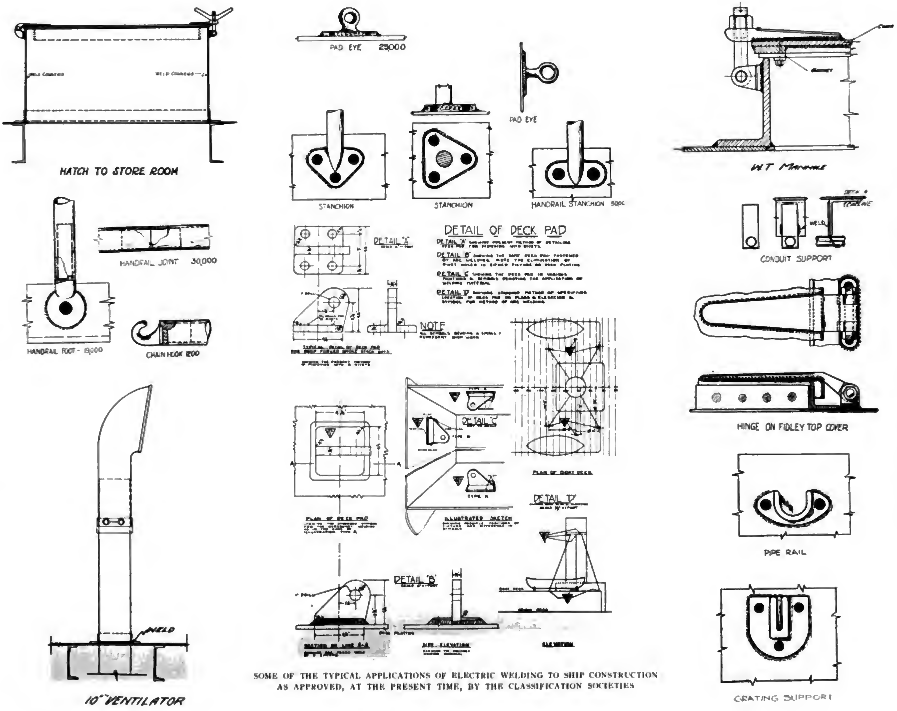
The type of equipment which can best be used in the shops is also somewhat dependent upon the local conditions. The layout of Hog Island permits the use of either direct-current type of equipment or an alternating-current type from the same plugs. Either the direct current or alternating current types of welder can be attached to the outlets at any place on the whole system. The voltage is in all cases, however, 440 volts, so that if any of the resistance, reactance, series type of equipment is used, a transformer is necessary to reduce the voltage to a safe value. This type of equipment, as single portable units, has been given less consideration than others, due to the power wastage.



ONE-MAN PORTABLE A. C. TRANSFORMER OUTFIT FOR ARC WELDING

DISTRIBUTION SYSTEMS

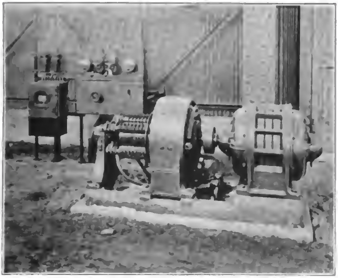
Coming now to the type and character of equipment for use on the vessels, local conditions again have considerable influence. If the ways are entirely protected from weather greater consideration can be given to portable rotating types. If the ways are exposed the question resolves itself into one of several. Portable rotating machines can be used with protective covers; series resistance, reactance type machines may be used in waterproof cases with low voltage distribution, carried down the ways to a suitable termination. Alternating-current portable transformer types of welders can be used. In two of these cases, that is, the direct-current, portable rotating type with protective cover or the alternating current type, comparatively high voltage—that is, 440 volts—



SOME OF THE TYPICAL APPLICATIONS OF ELECTRIC WELDING TO SHIP CONSTRUCTION AS APPROVED, AT THE PRESENT TIME, BY THE CLASSIFICATION SOCIETIES may be carried down the ways to a suitable termination, and the machines can be plugged in for use anywhere on the vessel.

At Hog Island we have carried the 440-volt, 3-phase system directly down the ways on each side of the vessel. Four outlets have been provided per ship; the distance between the two outlets on each side being about 200 feet. In this way it is possible to use the same type of portable machines as is proposed for the shops, that is, either direct current or alternating current.

Without discussing the relative merits of direct current versus alternating current as supplied either to the ship itself or in the shops, attention is called merely to the fact that the alternating-current type of machine which is now being used on the ships is light in weight, can be carried by two men, is not injured by any reasonable abuse, and will, as we know, produce satisfactory welds. The outlets as provided on the sides of the vessel are each capable of accommodating two welding machines; the maximum probable load, therefore, at the present time which could be accommodated per vessel would be eight. This could be added to to any reasonable degree without great difficulty.



D. C. MOTOR-GENERATOR SET FOR SUPPLYING EIGHT ARC WELDERS

The usual method of using types of machines either direct current or alternating current at the ship is to locate the welding machine within a reasonable distance, say 30 or 40 feet from the 440-volt plug outlet which is on the ways. The secondary lead is then carried from that point anywhere on the vessel. The method of handling leads of this character about a vessel for lighting and power, air lines, etc., is more or less familiar. The welding lead is carried in a similar manner, one terminal being attached to the hull of the vessel close to the welding machine. One difficulty with this method is, of course, the occasional adjustment to the welding current value. It is considered the helper's duty to take care of this at the demand of the welder.

GOOD WELDS AND GOOD WELDERS

Good electric welders have heretofore been comparatively scarce due to the fact that electric welding has been almost exclusively used in railroad shops and a few similar places. Due to the efforts of the Electric Welding Committee, it is expected that there will be a sufficient number of trained welders in the very near future to carry out practically any program which may be devised. Upon the men turned out by the Training Center of the Emergency Fleet Corporation depends to quite a large extent the future of electric welding. So many so-called welds have been presented to men unacquainted with the art, which have subsequently proven of absolutely no value, that the importance of good welders cannot be overestimated. The writer personally has seen sufficient to indicate that, provided good welders can be obtained, good ships can unquestionably be produced.

The illustrations indicate some of the welding which can be done in practically all shipbuilding yards. These sketches are more particularly applicable to the present "A" ships at Hog Island, the drawings for which had been quite largely completed and the work placed in the fabricating shops previous to the formation of the Electric Welding Committee. The result is that a large amount of labor had already been performed on these drawings and nothing was to be gained by substituting welding, except in a few special cases where partial fabrication had to be done on the vessel itself. In the case where holes have been drilled or punched in the shop, but where companion holes have to be made on the ship, the latter are being eliminated, the parts welded together, and the holes filled with welded material. In most cases this can be done at less than half the cost and time required to drill the holes. It is expected on the "B" vessels that practically all of the items shown in the illustrations will be welded and designed as such, with most likely a very large increase in their number.

The principal object of these sketches is to give an idea of the general parts where welding can be advantageously applied now. The direct question of how much time can be saved by welding methods as against the usual construction is, of course, dependent, first, upon the number of items welded, and, second, the character of the parts welded. Assuming the cost of labor to be the same per hour, and the power required for welding as equal to the power taken by the air or electric drill which normally would be used, it may be said, in general, that the time saving effected by welding the types of equipment which are shown in these illustrations would be not less than 70 per cent. of the time usually taken by old-established methods. The above figure, of course, is not intended to apply to a completely welded ship.

Fourth Discussion.

THE COVERED-ELECTRODE PROCESS*

By E. G. RIGBY
Vice President, Quasi-Arc Weldtrode Company

THOUGH the covered-electrode process for electric welding was established a couple of years, and making steady progress in industrial manufactures and gradually making its way into the shipyards, it was not until after 1914, when the great war started and our dockyards commenced to fill with damaged steamers and naval units crippled in their riveting and caulking as the result of vibration from gunfire, that the possibilities of electric welding as a means for their rapid and effective repair came to be realized. It was first taken up by the Royal Naval Dockyards, in a tentative way, but its successful application has now made it a most important part of every naval and private dockyard and shipbuilding plant. New and extended applications are coming into use every day. It was the writer's privilege to be associated with the work during this period, so gaining an experience that would not otherwise have been possible, ranging from the welding of a battleship's cast-steel stern frame, weighing upwards of 190 tons, broken in the launching, to the ordinary everyday jobs of welding angle-iron staples.

In the English shipyards the covered-electrode process has been largely adopted for repairs of all kinds, in conjunction with the usual methods of rivetting and smithing, for welding inside and outside seams for watertightness in place of caulking, reinforcing corroded plates in ships' bottoms, for oil tanks, bulkheads, cutting holes and welding studs in armor-plating for the attachment of bulges giving protection against torpedo attack.

In new construction work it has included the entire welding of sea-going hulls in place of riveting. In this, however, the way is being carefully felt, since the work is only in the initial stages and so far has been confined to the building of cross-channel barges of large size used in carrying munitions to France. The first of these boats was launched on July 11, 1918, and was welded throughout by the covered-electrode process, no rivets being used. From the experience and confidence gained in this way designs will be made for more important ship constructions, but welding engineers are still of opinion that the time has not yet arrived when it would be safe to weld throughout a ship of any size. It is confidently expected by prominent Naval architects that the cost of material and labor in building a ship will be reduced by some 20 per cent. when this time arrives. Even now 10 to 15 per cent. can be saved by using welding to the maximum of the limits already known to be safe.

All the large munition, engineering and steel plants of England use electric welding for repairs and for making good defective and fractured castings; for welding the seams of buoys, submarine mines, aerial torpedoes, bombs, shells, etc. In this connection hundreds of women are now engaged in welding by hand and automatic machinery, and similar methods have now been adopted here in this country.

The excellence of the work done by the covered-electrode process and the results of the many tests and experiments carried out by the British Admiralty and shipbuilders with it, has resulted in the authorities of Lloyd's Registry taking the matter up, and they are at the present time engaged in making an elaborate series of tests and experiments with a view to determining its further application to the welded construction of ships, boilers, etc. These tests have now been proceeding for over six months, and it is hoped that the results will shortly be available and that a more liberal policy towards welding will then be adopted by the classification authorities.

In the course of these experiments they have confirmed the conclusions the welding engineers had reached by actual experience, and it was found that the usual standard tension methods of testing welding were of little practical value, when considering the reliability of welding in connection with ship construction, where the stresses are almost wholly of a continuous alternating nature. It has long been established that metals, and particularly welds, will break under alternate stress at very much less than their elastic limits under either tension or compression. Welds, which are hard and brittle, and which have little or no elasticity, are manifestly not suitable to withstand stresses of this nature, or to withstand the shock stresses which often may be due to collisions or falling weights, which permanently strain the structure beyond its elastic limits. Tests are now being devised by the Classification authorities, and it is expected that they will insist that all welding processes and welding material to be used in shipbuilding shall be material or methods approved by them as having passed their tests. The requirements will probably be a reasonable resistance to breakage by alternate stressing, and that the welds shall withstand the shock of a weight dropped from a height sufficient to permanently deflect the joint without cracking it; and the sooner indiscriminate welding with any old material or operative is stopped the better it will be for all concerned. Hitherto, because of the poor results obtained by former methods, they have disallowed the use of autogenous or fusion welding in any joints carrying tensile stresses, while permitting it in some places not coming under stress, or where a failure in the weld would not be vital.

The wider adoption of electric welding in shipbuilding, wherever it can now be usefully employed, is a matter of supreme importance at the present time when the demand for tonnage is so great and urgent. In addition to the large reduction in weight of material for a given strength due to dispensing with the angle frame attachments, laps and rivets, there is an important economy in the lighter weight of plating which may be used owing to the fact that joints or seams of greater efficiency can be made by welding. It also brings in its train a reduction of the necessary man power connected with the skilled trades in punching, rivetting, caulking and smithing, and a large saving in time and plant equipment as compared with present methods of construction.

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* Delivered in the Auditorium of the Engineers' Club of Philadelphia, August 24, 1918.

ADVANTAGES OF ELECTRIC WELDING

The superiority of electric welding over gas and fire welding is consequent upon the extremely localized character of the heat generated by the electric arc, thereby resulting in a smaller area of the disturbance, and also in the elimination of the necessity for any pre-heating of the work to be welded. The difficulty of localizing the heat in gas welding is liable to lead to imperfect welding at certain places of junction, owing to such places not having been brought to a welding temperature; and has the further disadvantage (owing to the wide area over which the heat is diffused), that the welds are usually left in a condition of greater stress, due to the contraction of the cooling metal.

DEFECTS OF FORMER ELECTRICAL METHODS

Fusion welding by electrical energy has been hitherto effected either by means of the carbon arc or by using plain iron rods as electrodes. Such welds are frequently deteriorated by pitting, due to the particles of slag which is formed in the fusion, adhering to the surfaces, and oxidation due to the fused metal, exposed to the atmosphere, absorbing oxygen which reacts and combines with the carbon in the steel to form gas, and with iron to form oxide, resulting in brittleness and porosity and breaking up the structure of the metal.

The importance of forming a joint which contains no trace of oxide is so great as to deserve particular emphasis. Not only does the presence of oxide greatly reduce the strength of the weld and destroy its elastic limits, but it renders the joint peculiarly liable to corrosion, and in view of the importance which the subject of corrosion bears to that of welding, especially in shipbuilding or exposed joints, the following points are of interest:

1. Fundamentally corrosion is electrolytic in character and depends on the difference in potential of contiguous areas.

2. Commercial iron and steel contain areas which in the presence of an electrolyte (which may be merely atmospheric moisture) are capable of forming voltaic circuits, the necessary conditions being afforded by the presence of small particles of impurities, or by local conditions of strain in the metal itself.

3. These impurities or strains give rise to areas of higher electrolytic potential, and form the electro-positive points which are first attacked by the corroding agent. Thus in a caulked joint corrosion will commence at the caulking, and similarly a rivetted joint will be attacked around the rivet head, owing to the local strains in the metal at these points.

4. In a welded joint, if the metal at the weld be less pure than the surrounding metal, the weld will be first attacked. Similarly, if the added metal be not homogeneous, local differences in potential in the weld itself will cause corrosion at the weld.

COVERED-ELECTRODE PROCESS

This process is entirely different in method and result from the Bare-Wire-Metallic, or carbon-arc fusion processes. It is more rapid and perfect, owing to the fact that the heat introduced into the weld is automatically governed by the nature of the special electrode, the covering of which in the solid state is a non-conductor, and in its molten state a good conductor of electric current. As a secondary conductor the slag automatically maintains electrical connection between the work and the metallic arc of the electrode, serving to confine and maintain the direction and length of the arc, thus necessitating less skill on the part of the operator to hold a continuous arc.

In operation, electrical contact is made by touching the work with the end of the electrode held vertically, thus allowing current to pass and an arc to form. The electrode, still kept in contact with the work, is then dropped to an angle, when the arc is immediately destroyed, owing to the special covering passing into the igneous state. The action once started, the electrode melts at a uniform rate so long as it remains in contact, and leaves a seam of metal perfectly diffused into the work, the covering material forming a slag, floats, and spreads over the surface of the weld as it is made.

COVERED ELECTRODES

These electrodes are composed of a metallic core, with a covering of blue asbestos yarn, which is a ferrous silicate, and in fusing acts as a reducing agent, and by excluding the atmosphere from the fused metal effectually prevents oxidation of the deposited metal. The yarn is coated with sodium silicate, aluminum silicate, or the like to vary the fusing temperature of the asbestos yarn.

This covering forms a fusible insulating casing around the metal core of such thickness that the metal core is supported by it, when in contact with the work, at the proper distance, and thus to a large extent eliminates the factor of manual dexterity in maintaining an arc of the proper length while the electrode is fusing. In addition to the fusible insulating covering, the electrode has combined with it a small quantity of a different metal capable of exerting a strong reducing action, that is a metal such as aluminum having a strong affinity for oxygen at the temperature at which the welding takes place.

Aluminum is admirable for the purpose, and is applied in the form of a fine wire wrapped in the blue asbestos covering. The aluminum, as it fuses with the metallic core of the electrode, absorbs the small amount of oxygen which may be present in the slag, and so prevents oxidation of the fusing metals. The aluminum formed readily combines with, and passes away with, the slag, and so produces, in the hands of a competent welder, a homogeneous deposit in the weld. Owing to its reducing action, it also preserves to a considerable extent the original carbon content of the steel from the oxidation which usually occurs in fusion.

CUTTING WITH COVERED ELECTRODES

Steel plates or castings can be readily cut by the electrodes and this feature is exceedingly useful when the oxygen blowpipe is not available. The method of procedure is to take a mild steel electrode, dip it in water, and with a relatively high current, apply the point of the electrode to the plate or piece to be cut. The point of the electrode must be moved quickly up and down through the thickness of the plate, and the molten metal allowed to drop.

THE EQUIPMENT FOR COVERED-ELECTRODE WELDING

The equipment for this process of arc-welding is very simple and relatively inexpensive. Any source of current supply either A. C. or D. C., at a pressure of 100-110 volts may be utilized, and the maximum amount of current used by any one operator will not exceed 200 amperes for the heaviest welding or cutting operations.

THE NECESSITY FOR TRAINING OPERATORS

The rapid and wide adoption of electric welding in England and France, as also in this country, brought about by the necessities of the war situation, has led to a great demand for operators, and the irregular quality of the work produced, as the result of improper methods of preparation, and of employing partially-trained workmen, directs attention to the reason why electric welding has been so long in taking the prominent place in constructional work which its merits deserve.

Hitherto it has been the practice to hold out the statement that, by adopting electric arc welding, any handy man could do this welding work. While this may be true as regards some class of work more or less automatic, it certainly does not apply to such work as is found necessary in shipbuilding, or the welding required in the general and repair work of an engineering workshop. There has been no recognized trade of electric welding and no proper means of instruction for electric welders.

In the case of gas welding, which hitherto has had the field almost to itself, the trade has been better organized, and some attention has been paid to properly instructing workmen, and literature on the subject is plentiful.

In electric welding, however, it was usual to buy an outfit, turn it over to a handy man and expect him to turn out good work, right from the start, without instruction. If he failed, electric welding methods got the blame, and the outfit was put aside. This is the case even to-day. Welding with the electric arc is a trade of some skill, and requires both practice, to acquire the manual dexterity to manipulate it properly, and instruction in the proper use of the apparatus employed, and the control and regulation of the current necessary to perform any given piece of work. Both the size of the electrode used and the mass of the work will vary in different jobs, thus necessitating different current flows and amounts of heat. as well as different methods of preparing the work, with all of which the operator should be familiar.

Such knowledge is only elementary, but it is very necessary, to enable the operator to make any intelligent use of electric welding. Electric welding requires not only skill, but also a great deal of practice and experience; and it is just as sensible to expect a handy man to do consistent work with it, without instruction and practice, as to put the same man to a blacksmith's fire and expect him to make first-rate forgings at the first attempt.

Failures are not always the fault of the workman; it is just as necessary to provide him with proper appliances and proper electric current conditions, as to provide the blacksmith with a suitable forge, fire and fuel. The writer has frequently been called to yards, even in this country, where complaints have been made that the welding was not satisfactory, and found that the trouble was wholly because the proper current conditions had not been provided. In one late case here, where a maximum of 110 volts was stipulated, the current was found to be 220 volts, and in addition the circuit was so overloaded that only the smallest diameter electrodes could be fused, and that only intermittently. One might just as well expect his blacksmith to weld 6-inch angles and give him a rivet-heating fire to work with.

Soon welding by means of the electric arc will supersede many of the riveted applications of to-day; and designers of ships and structural work will re-arrange their details to suit it, so soon as they have confidence that they can get operators able to make consistently good welded work that compares favorably with the results of the tests and experiments that have already been carried out.

In Great Britain these facts are now being recognized. Most of the large shipyards and electric-welding companies have arranged special classes and training shops to give men proper instruction and practice under competent welders before sending them out to do work in the yards. It usually takes three or four weeks to acquire the necessary skill to handle the electrode properly in the various positions in which the operator will be called upon to work, and sometimes longer to acquire enough experience to know whether the work he is doing is sound or otherwise.

CONDITIONS REQUIRED FOR GOOD WELDING

The idea at present seems to be fairly prevalent that the principal value of electric welding in a shipyard is to cover up mistakes, and that it can be used to make an efficient welded joint no matter what its shape or width may be, so long as there is a crack or gap into which metal can be melted. This is fallacious and should be discouraged. As an instance, we were lately asked by the foreman of the welders in a shipyard, to whom we were making a demonstration of our plant, to weld up a gap left by a shortage between two plates, which he had filled up by jamming a row of punch burrs into the gap, and when we objected he told us "that is the way we do it." Slipshod methods of this kind will have to go, if electric welding is to be recognized as an essential part of the shipbuilding industry, and the inspectors of the Classification Societies are doing good work by their conservative attitude while this state of affairs exists.

Long seams and joints such as are necessary in welded ship construction, require careful consideration by the engineer, who will study the effects of expansion and contraction and make provision for it. Mechanically, such a seam is only a matter of careful intelligent assembly, just as is required for riveting; the edges of the joining plates must be prepared to shape with the same accuracy and care as the rivet holes now are; the various parts must be assembled, with the meeting edges of the plates in the positions they are to occupy permanently, by means of an ample number of temporary service bolts, hook bolts, male brackets or the like, exactly in the same way as for rivetting. The holes required for the assembly will be filled up with studs welded in after the seam weld is completed.

When the assembly is complete, the plates should be tacked together at intervals by short welds, particularly at the ends, and to any frames with which they are to connect. The seam should be welded first along the bottom of the V with a small electrode and filled up afterwards with one or more runs of welding as may be required. The assembly bolts should be left in position wherever possible till the weld is completed. The weld should be inspected between each run of welding, and any bad or doubtful places cut out with a diamond-pointed air chisel before the next layer is put down. This gives a check on the welder as well as his work.

THE APPLICATION OF ELECTRIC WELDING IN SHIP CONSTRUCTION

When autogenous welding was first introduced it was doubtless thought that it could replace without further difficulty the existing methods of connecting plates and so forth by rivets. Autogenous welding, however, either with a hot flame or with electrodes has been known in practice now for a great many years, and its applications have become very varied, but still it has not yet displaced the method of riveting employed in large metallic structures such as ships, for joining together plating and frame members. It may well be that in a short time electric welding will enable this advance to be made. The purpose, however, of this paper is to draw attention to certain particular methods of employing electric welding in ship construction, which render such welding methods applicable and practically advantageous for these purposes, and it will be realized that it is necessary to deal with the problem of ship construction in detail, applying welding first in the manner which is most advantageous, in order to ascertain its practical advantages, and to test its utility under all service conditions. The importance in the writer's view of the designs to which attention is now called, resides in the fact that they are the first, as far as is known, in which welding as applied to practical ship construction is considered in detail from the engineering point of view, while the designs have the further advantage that they can be tested without departing in any important respect from existing plans and practice in ship design, so that no practical risks are involved.

ELECTRIC WELDING AS APPLIED TO SHIP'S DECK STRUCTURES, BULKHEAD STRUCTURES, ETC.

The design shown in sketch No. 1 relates to deck constructions, bulkhead constructions and the like. In ship construction there are always frame members, usually of channel-or Z-section at intervals of about two or three feet apart inside the plating of the sides, and in order to build in the deck it is necessary to cut the deck so as to fit over the frame members. Angle-iron collars are forged to fit inside the channels of the frame members, around said members, and along the plating between them, the collars being riveted to the ship's plating and the frame members, and riveted also to the decks. It is usually required to make bulkheads and partitions also to fit against the ship's sides in the same way by the use of angle-irons fitted around and between any brackets and stringers, and riveted to the plating and the bulkheads. Then it is necessary to make such decks and bulkheads watertight by caulking the joint lines between these and the decks, and all the rivet heads, but even so, it is almost impossible to caulk every joint effectively, particularly around the longitudinal stringers and so forth. The result is that there is always a certain amount of leakage which may steadily become worse, owing to the inevitable relative movements due to the working of the ship, and also creaking is liable to occur due to relative movements, particularly against and around the frame members. The object of the present design is to provide an alternative method of fitting and fixing decks, bulkheads and the like in ships, which will overcome these disadvantages with a notable saving in labor, material and deadweight.

Figure 1 shows in elevation a portion of the plating at the side of a ship and a portion of the deck in section, while

Figure 2 shows a plan of Figure 1;

Figure 3 is a detailed view showing a section of the line A-B of Figure 2, and

Figure 4 shows a section on the line C-D of Figure 2.

In the drawings, *a* is the ship's plating, for example, at one side of the ship, *b* are the frame members extending upwardly and downwardly, and *c* is the deck to be inserted. Between each frame member and the next an

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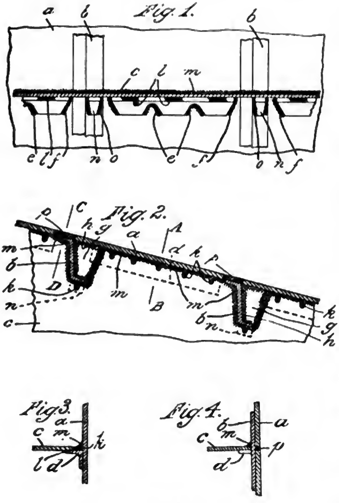

SKETCH 1

angle-iron bracket *d* is fitted, being held in position against the ship's plating *a* by welding deposits as at *e*, Figure 1, in notches cut in the vertical webs of the brackets, and by welding deposits *f* at the chamfered ends of said brackets. One object of cutting the notches *e* and welding up to the tips thereof, is to insure that the brackets *d* are supported near the top, and will not therefore be liable to be torn away from the plating by any weight resting on the deck, which in turn bears upon the projecting tops of the brackets. The notches may be cut in the webs of the brackets *d* at intervals of say 6 inches apart, and they may be of any convenient shape, but an inverted V-shape with a rounded end is generally the most suitable in practice. The brackets are not required to extend at each end up to the upright frame members *b*, but they may be cut in lengths from straight angle bars so as to fill approximately the gaps between said frame members *b*. The tops of the brackets *d* are at the level to support the deck directly. Small additional brackets *n* may also be applied to the faces of the frame members *b*, at the same level as the angle-iron brackets *d* in order to support the deck at the faces of said frame members. The brackets *n* are welded to the frame members *b* by fillets of deposited metal *o*, as indicated in Figure 1. The irregular internal sections of the frame members *b* are filled in at the level of the deck *c* with insertions *g*, Figure 2, these being welded into the section of the frame members *b* by fillets of welding metal *h* around the inside of the said frame members and against the ship's plating *a*. The insertions *g* when fitted in this way fill up the gaps in the frame members at the level of the deck *c*, leaving a plain or simple non-reëntrant section around which the deck can be fitted easily and closely.

The deck may be assumed to be made up of metal plating which is riveted or welded together in any convenient manner. It may be treated as if it were a single plate for the purposes of this design. When the deck is inserted it fits against the sides of the ship's plating and around the brackets *b* and insertions *g* as shown, and it is first welded down on to the tops of the brackets *d*, and the brackets *n* also if desired, by welding deposits applied as at *k* in notches or slots cut at convenient intervals in the edges of the deck, Figure 2. Alternatively or in addition, the deck might be welded to the flanges of the brackets from beneath by fillets of welding metal deposited at *l* in Figure 3, but this is not generally necessary. Then a line or fillet of welding metal is deposited all round the edge of the deck as indicated at *m*, both against the ship's plating *a*, and around the brackets *b* and insertions *g*. In this way the deck is completely welded and hermetically sealed in place in the ship, so that no subsequent caulking or labor of any kind is required upon it to make it watertight.

Water might still find its way between the frames *b* and the ship's plating *a* (unless they were packed with jointing material which is not permanent, and in order to render impossible leakage of water at this point it is preferred to cut slots in the plating *a* from the outside adjacent to the frame members at the level of the decks, and to weld the frame members and plating together through such slots as at *p*, Figures 2 and 4. In this way a complete line of welding is formed at the deck level along the ship's plating.

The fitting of bulkheads in place is effected in exactly the same manner as for the decks, upright angle brackets being welded to the ship's plating, and the bulkheads being welded to such brackets and to the plating. If Figures 1 and 2 are regarded as being turned through 90° they will represent the insertion of such a bulkhead, the frame members *b* being then horizontal frame members which occur at intervals inside the ship's plating.

As the necessity for the drilling of rivet holes in fitting the decks and bulkheads is entirely eliminated, and as electric welding can be done by a single person, whereas riveting required the simultaneous labor of three men as a rule, it is evident that this method of inserting the decks and bulkheads may introduce an important economy in labor, in addition to its other advantages.

THIS IS THE FIRST OF THE 10 GOOD REASONS

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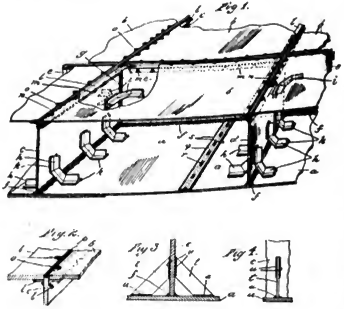
THE APPLICATION TO KEEL PLATES, PARTITION PLATES, ETC.

This design (see sketch No. 2) relates in particular to the method of inserting the vertical keel plates, the longitudinal partition plates, the intermediate cross-partitions or plates, and the inner shell which is carried on or secured to the framework formed by such plates. Hitherto it has been usual to secure the vertical keel plates and partitions in place by means of angle-iron brackets riveted to the keel and the ship's bottom plating, and to secure the inner shell plating of the ship to such vertical plates by brackets riveted to said plates and to the inner shell. In order to make the structure water- and oil-tight it is necessary to caulk every joint and all the rivets, but even when the ship is new the joints are rarely fluid-tight throughout, and after a time they are sure to loosen more owing to vibration and to racking stresses.



SKETCH 2

These difficulties can be avoided, and an improved structure is provided by a method of welding, whereby the whole labor of riveting and all necessity for caulking is avoided. It might have been thought that it would be sufficient to employ angle irons as before, and merely to weld them instead of riveting them in place, and this has been previously proposed, but though this might present some advantages over riveting, it does not provide nearly so strong or effective a structure as is provided by the construction shown in this plan.

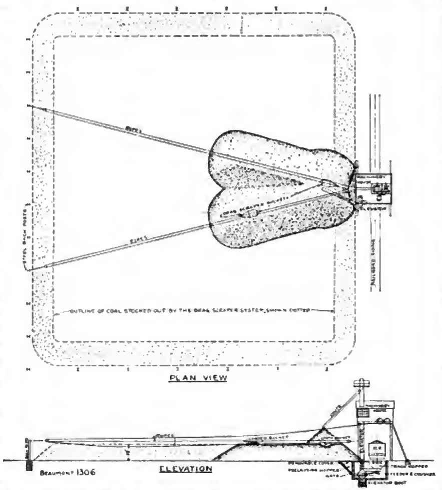
Figure 1 illustrates in perspective, and partly broken away, a portion of a ship's bottom and inner shell plating or false bottom, with the intervening keel and partition plating.

Figure 2 shows in perspective a slight modification. Figures 3 and 4 are two views at right angles showing another modification.

Referring to Figure 1, the ship's bottom plating is marked *a*, and the inner shell plating *b*. A portion of the vertical keel plating is seen at *c*, while *d* is another longitudinal line of partition plating, and *e* is the intermediate cross-partition plating. The vertical keel plate *c*, and the longitudinal partitions *d* are laid along the bottom plating *a* of the ship, and are fillet-welded thereto along their bottom edges at both sides, as indicated at *f*. The transverse intermediate partition plates *e* are similarly placed and welded, both to the ship's bottom plating as at *f*, and also to the longitudinal partitions *c* and *d*, as seen at *g*. The joints so made would not effectively resist racking stresses, but the necessary strength and rigidity is obtained separately, by making struts *h* of angle- or T-iron, and welding them at intervals to the vertical keel plates *c* and partition plates *d* at the one end, and to the ship's bottom plating *a* at the other end. The struts may be shaped from suitable section irons, with ends at the proper angle to the middle portions in order to lie flat against the plates to which they are to be welded; and the welding is done either around the said ends of the struts as indicated at *k*, or through slots or notches cut therein, or in both of these ways. Instead of struts *h*, plain gusset plates *t* may be used, these being cut from metal plates and welded around their ends as shown at *u* in Figures 3 and 4. The term "struts" where used hereinafter, is to be read as including such gusset plates. In the welding of these struts, owing to the fact that the struts are of much less mass than the plates, they become more highly heated, and therefore expand more than the plates. On cooling after the welding, therefore, the struts *h* or *t*, which extend at an angle from the vertical keel and partition plates *c* and *d* to the bottom plating *a* of the ship as shown, tend to contract more than the plates, with the result that all the struts are left in tension while the vertical keel and partition plates *c* and *d* are in compression between the ends of the struts and the ship's bottom plating *a*. Hence a rigid trussed structure is formed which is admirably adapted to resist all racking, bending or vibrational stresses. The struts may be placed in pairs at opposite sides of the vertical plates as shown, or in staggered positions as may be preferred, and will be fixed at intervals apart depending upon their strengthened section. Similar struts *i* may be arranged and welded in horizontal positions at the corners where the longitudinal and transverse partition walls meet.

It will be seen that the structure depends to a large extent for its rigidity on the struts, and that these play no part in rendering it fluid-tight. The fillet welds *f* along the lower edges of the plates and at *g* between the longitudinal and intermediate partition plates, serve this latter purpose in an entirely effective and permanent manner, while at the same time they prevent any possibility of movement or shearing between the vertical plates *c*, *d* and *e* and the ship's plating *a*.

The vertical keel plates *c*, the longitudinal partitions *d* and transverse intermediate partitions *e* form a structure or framework which provides a number of oblong cells or spaces, and instead of forming the inner plating or



The Beaumont Drag Scraper for Coal Storage

COAL is received at the plant in railroad cars, discharged into the hopper below the tracks and conveyed mechanically to the crusher, where it is reduced to stoker size. A chain and bucket elevator picks up the coal, after it has been crushed, elevating it for about 50 feet, and delivers it down a chute to a large pile of coal about 20 feet high, which is adjacent to the railroad track. A machinery house, located above the railroad track, contains a pair of rope drums which propel ropes over the storage yard, the ropes having two scoops attached to them. These scoops are quickly detachable so that they can be turned around to reclaim the coal. Around the edge of the yard are located steel posts. To store coal at any portion of the storage yard it is only necessary to change the tail sheaves from one post to another.

When reclaiming the coal it is scraped back to the reclaiming hopper and delivered to the bucket elevator mentioned previously. This elevator will discharge the coal either to railroad cars or to a conveyor leading to the boiler house.

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bottom *b* of the ship so as to lie over this, the inner plating is fitted as follows: Angle brackets *l* are welded to the vertical keel and partitions *c*, *d* and *e* at intervals, preferably by notching or slotting the vertical webs of the brackets at suitable points as at *m* and welding the edges thereof to the vertical plates, and then filling in the notches or slots with deposits of welding metal so as to provide solid supporting pieces. The tops of the brackets *l* are disposed the plating-thickness below the tops of the partitions *c*, *d* and *e*, and templates are cut to fit in the cells, the inner plating *b* being made up in complete sections therefrom, one section for each cell of the partition structure. The inner plating sections *b* may have chamfered edges as shown in Figure 1, and when they are inserted, deposits of welding metal are made at *n* to fill in the V-shaped spaces and to weld the plating *b* to the vertical keel and partition plating *c*, *d* and *e*. The plates *b* are also preferably slotted or notched at intervals at or near their edges as at *c*, and are welded to the tops of the brackets *l* by deposits at these points before the edges of the plates are welded all round as at *n* to the vertical plating *c*, *d* and *e*.

In the alternative construction shown in Figure 2, the brackets *l* are such of a height that the inner plating *b* when inserted, stands up half-proud of the vertical plating *c*, *d* and *e*. After the welds in the notches *c*, holding the plating *b* to the brackets are made, fillet welds are then made around the entire edges of each section of the inter-plating *b*, upon the tops of the partitions *c*, *d* and *e*, and these joint lines are finally filled in also with welding metal as at *p*. The result is to form an inner plating for the ship, in sections *b*, which are completely welded to the partition walls *c*, *d* and *e*, all round the same, and are also welded one to another along their edges, so that a very strong and rigid structure is provided which is completely fluid-tight, without the necessity of any caulking.

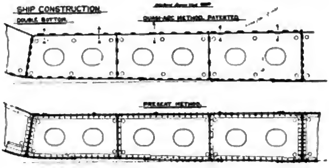
The structure is substantially the same for the partition plates and inner plating of the ship as far as these are carried up the ship's sides past the bilge keels, except that in the dies there is not the same necessity for making the longitudinal partitions all fluid-tight, and one line or fillet of welding on the upper edge of each partition plate may suffice, while the flanges of the struts on which the plates rest may be welded from above to the partition plates through slots therein.

The construction set forth has an advantage in saving dead weight, and consequently in reducing the displacement of the ship.

INNER PLATING, MORTICE AND TENON JOINTS

In this construction, sketch No. 3, the inner plating, floors and so forth, are applied in lengths, extending over the partitions, while fitting thereon by mortice and tenon joints which are secured by welding. In addition, where required, watertightness may be secured by fillet welding along the angles or junctions between the partitions and the plating, or along portions thereof not already welded.

The partition plates are formed with projection at intervals constituting tenons. This may be done before the plates are inserted, by punching out the intermediate portions at the inner edges of the plates so as to leave the required number of projecting tenons; or in any other convenient manner according to circumstances. One possible alternative is to weld tenons to the tops of the partitions, or into slots cut therein. When the partition plating is complete, with such tenons projecting therefrom, the inner plating in convenient lengths is laid thereon, having been shaped and punched or slotted in advance with mortice slots to fit over the tenons on the partition plating. The slots are made substantially longer than the tenons for reasons stated below, so that great accuracy is not required in cutting. The welding is then effected by deposits of welding metal in the slots around the tenons and at each end thereof. In order to hold down the plates during this welding any convenient forms of temporary attachment devices may be used, for example hook bolts engaging in the limber holes and other holes in the partition plating may be used, these bolts projecting through holes in the plating to be welded on, and being tightened by nuts from above. The hook bolts can be removed when the welding is completed around the tenons in the mortice slots, and the holes where the hook bolts have been placed can be filled up if required, for example, in the case of oil-tight or watertight plating, with plugs driven in and welded over, or in any other convenient manner.



SKETCH 3

It is important that the mortice slots should be substantially longer than the tenons in order to enable the welding metal to connect the partition members to the plating throughout the thickness of the latter; the slots are also wider than the tenons, to allow of welding along each side thereof, in a V-shaped space or otherwise. Each tenon may be divided into two or more projections with welding between them if preferred. The inner plating, tank tops, floor and the like, can be made by this method in sections of any convenient length or breadth, and secured upon or against the partition plating by welded mortice and tenon connections, both longitudinally and transversely. One section of the plating can be connected to another by welded butt joints, welded lap joints or welded butt strap joints, whichever may be most convenient or suitable in any particular case. When the con-

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nection between the inner shell plating, floors or tank tops and the partition plating is to be made watertight at any particular line of connection where mortice and tenon joints have been made, a fillet of welding metal will preferably be deposited at the under side of the plating against the partition walls, either throughout the whole length or only in the intervals between the tenons.

The method of mortice and tenon welding provides the strongest and simplest form of joint, and involves comparatively little welding, much welding being of an easy character as it is in slots open above.

Where the ends or sides of lengths or sections of the plating are to be connected together in position not coinciding with a partition wall, it depends upon the strength required in the joint which type of joint shall be adopted. A plain abutting joint is sufficiently strong for many purposes, the abutting edges of the plates being preferably cut to a V-shape to receive the weld of deposited metal. In the case of a lap joint which will give greater strength as a rule, the edge of one plate will generally be joggled to overlap the other, and a complete fillet weld will be run along the overlapping edge at the top, while, if necessary, welds at intervals may be provided along the exposed edge from beneath, or even a complete fillet underneath. This will rarely be necessary. If a butt strap is used applied from below, it will be held up generally by service bolts at a few points, the plate edges to be joined being preferably spaced a short distance apart so that the slot thus left can be filled in with deposited welding metal uniting the butt strap to both plates, and uniting the plates directly. The service bolt holes are afterwards filled in with welded plugs or otherwise, when required.

However the plates are jointed together, they are secured by the mortice and tenon joints in a very strong and effective manner to the partition plating, while they are not weakened by rivet holes, and a substantial saving is effected in deadweight and in labor involved in construction.

The remaining sketches, though illustrating very simple constructions, are the result of an immense amount of thought and numerous experiments arising from the exigencies of the British Dockyards in dealing with the necessary repairs to the many Naval units of all descriptions, which came into port after engagements, with their caulking and riveting all gone to pieces, caused by the vibration and shock stresses of heavy gunfire.

Everyone knows the difficulties encountered and time required to make repairs in such cases by mechanical caulking, and the uselessness of caulking unless the rivets are first taken out, holes reamed, and new and larger rivets substituted. In many cases in the completed structures this is practically impossible. The ships, however, were needed, and that with the least possible delay in dock, so some substitute for the older methods had to be found.

It was here that arc-welding was finally resorted to, and to-day it is universally used by the Naval Dockyards, with very great effectiveness, both in saving of time and in efficiency.

METAL PLATE STRUCTURES OF SHIPS, TANKS, ETC.

The design shown in sketch No. 4, relates to metal plate structures of ships, tanks, and the like, which are required to be watertight. In structures of this character which are liable to be subjected to heavy stresses, no caulking can be permanently effective, and it is liable to break down very quickly in structures such as plated vessels after heavy gun firing. What is required in order to render such a structure watertight, is to provide some form of elastic sealing medium which will cover all of the joints, and will not be destroyed by the maximum strains and deformations to which the plating structure is liable. There is no satisfactory elastic medium of a non-metallic nature which could be used, or which has been successfully applied to the purpose in view, and it is the object of this design to attain the result with a metallic structure, using methods of welding for securing the projecting sheets.

Comparatively thin and flexible metal sheets are used which will cover the joint lines, the sheets being welded to the plating in order to eliminate all risk of leakage. In preparing sheets for the purpose rolled steel plates may be used of a comparatively thin gauge, for example, No. 12 gauge, and these sheets are annealed throughout in order that their consistency may be as uniform as possible after welding. They are laid over the joint lines and are fillet-welded at their edges to the plates at each side of the joints.

Figures 1 and 2 show riveted plating with comparatively narrow steel strips *a* laid over the joint lines and welded at each side to the plates by means of deposited fillet welds at *b*. Where one strip meets another over a plate joint, the end of the abutting strip is welded to the edge of the outer strip or to the plating as at *c*. Figure 1. In this example, the applied strips *a* may be only, say from 1 to 2 inches broad so that they will lie inside the lines of rivets *d*, as shown. The steel strips *a* can be fed down against the surface of the plating as they are being welded, in the manner illustrated in Figure 3, the ends of successive strips being united by welding where more than one length of strip is required for a joint. The resultant structure is absolutely watertight and will withstand very high stresses without showing any signs of leakage. With stresses large enough to open the joints somewhat, the thin annealed steel strips can extend or bend transversely to the extent required without their welded edges breaking away. Even with no caulking between the edges of the plates of the structure, therefore, it is a great improvement on existing plating

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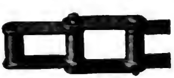

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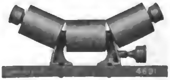

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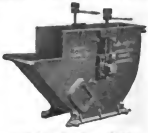

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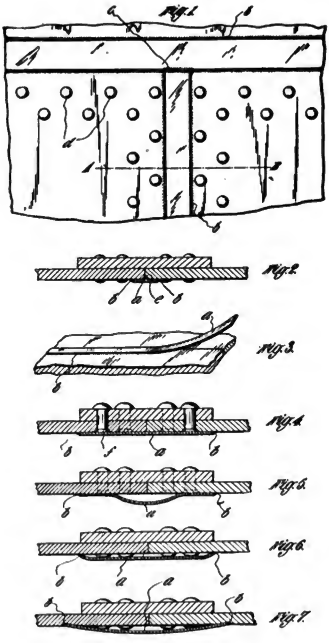

SKETCH 4

structures as regards resistance to opening up of the joints and risk of leakage. The actual joint line may also be caulked, for example, at *c*, Figure 2, before the steel strip is applied with a run of deposited welding metal whenever this is considered desirable, and this will further strengthen the joint and increase its resistance to opening stresses. Mechanical caulking can also be used.

The applied strips *a* need not necessarily lie flat against the plating, but they may be buckled outwardly somewhat from it in order to allow freedom of expansion, or slightly waved or corrugated in a direction extending along the joint line. This is illustrated in Figure 5. If the rivet heads project, as in Figure 6, the steel strips may be bent inwardly at their edges beyond the rivet lines and welded there. This also provides an element of flexibility in the middle part of the strip which is held out at a little distance from the surface of the plating.

The edges of the covering strips may be also be let into recesses in the metal plating if desired, as indicated in Figure 7, but as a rule this should not be necessary as the fillet welds *b* at the edges will prevent any sharp corners being left.

In any such cases as those of Figures 5, 6 and 7, wherein the strips are curved and extend away from the plating surface over part of their width, the ends of the strips may either be flattened down to enable them to be welded to the plating or to crossing strips, or such crossing strips may have their edges lifted to apply them to the ends of the first mentioned strips, whichever may be most convenient.

ATTACHMENT OF FITTINGS TO HARDENED PLATE SURFACES

This design relates to methods of securing attachments to iron or steel plating which is too hard at its surface to permit of drilling and inserting studs, bolts and so forth.

Figure 1 shows in section the method of securing a stud in the plating.

Figure 2 is a face view of one of the holes with a stud therein.

Figure 3 shows a cross section on the line 3-3 of Figure 2.

Figure 4 shows a jig for holding several studs ready for welding in place.

Figures 5 and 6 are sectional views corresponding to Figure 1, showing subsequent stages in the operation.

In the drawings, *a* represents a surface-hardened plate such as armor plating. In this the hardening extends say for one and a half inches inwards from the surface as indicated by the dotted line *b*. Nothing can be secured to this surface by welding, as the welding deposit, if applied, merely breaks away a portion of the hardened metal with it when any stress is applied to it. If, however, the high-carbon steel at the surface could be pierced, the milder metal at the rear would serve for effecting a secure attachment by welding. This is carried out as follows:

Holes are burnt or fused out at the required distance apart for studs, which will provide a secure attachment for the further plate or other object to be mounted on the hardened plate. For burning the holes through the hardened layer of metal the electrodes are preferably moistened in order that an oxidising action may take place, and a heavier electric current is used than is required for effecting electric welding. In this way a series of holes are formed preferably of the shape indicated at *c* in Figures 1 to 3, and extending to a depth well beyond the plane indicated at *b*, where the surface hardening ceases. The holes are oval in form and undercut at the ends, so that when a stud such as *d* is laid in one of the holes, there will be space enough above and at each side of it for inserting and manipulating a welding electrode in the hole. A series of such studs is placed in the row

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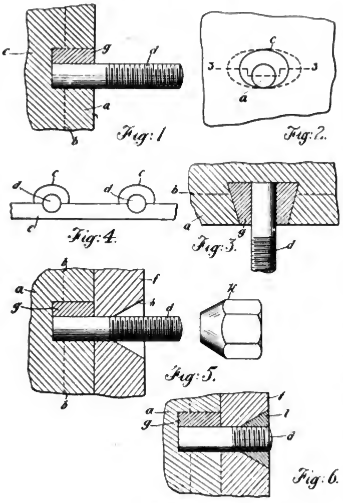
of holes, and held in the right position for fitting in corresponding holes in the object to be attached; the holding may be accomplished by the use of a suitable support or jig such as is indicated at *e* in Figure 4. Each hole *c* is then filled up solidly around the stud *d* with welding metal, built up from the rear, where it coalesces with the milder backing metal or the armor plate *a*, until a conical-ended block *g* of metal is formed, welding the stud *d* to the backing metal, and boring it into the hardened surface metal so that it cannot possibly pull out.



SKETCH 5

The studs *d* are all preferably screw threaded, as indicated, and the object to be attached, for example a further plate *f*, is now applied, with its ready-formed holes fitting over the studs *d* as they project from the plate *a*. The holes in the plate *f* are chamfered out at the front as at *h*, Figure 5, and nuts *k* preferably formed with coned ends as shown in Figure 5, are now applied to all the projecting studs, and are screwed up tightly to secure the plate *f* firmly in position. The surfaces of the welds *g* are, of course, smoothed or filed flat if necessary, before the plate *f* is applied.

Finally, the nuts *k* are removed one by one, and the annular spaces provided by the chamfered holes *h* are filled in with deposits of welding metal *l*, Figure 6, which draw the plate *f* even more tightly against the plate *a* as the heated studs *d* and the deposited metal cool. Removing the nuts *k* only one by one as the welds are made, prevents any risk of the stresses due to the heating and cooling in the welding operation distorting the plate *f* and so interfering with its proper positioning. When all the welds are made, or as each nut is removed and before the welding which replaces it is effected, the projecting ends of the studs *d* can be cut off flush or nearly so, leaving a finished attachment such as is seen in section in Figure 6.

If the object *f*, which is secured, is a bracket or the like, it can be employed in turn for supporting any other object or plate which it is required to mount upon the hard-surfaced plating *a*. The holes *e* are not necessarily of the precise shape shown, and they might be circular and conical, for example, with the studs *d* placed at the center. This would usually necessitate the use of larger holes and would result in more labor and expenditure upon electrodes in the cutting and subsequent welding operation, so that holes of the general shape indicated are preferred. The undercutting is important in keying the welding deposits *g* in position, but it is of even greater importance to insure that each hole *c* extends beyond the very hard surface layer of the plate *a* into the milder metal at the rear, as otherwise no reliable attachment would be made. The studs *d* are not necessarily placed in straight rows, of course, but their number and disposition will depend upon the form and mass of the object to be attached, or the stresses to be borne subsequently. For some purposes possibly it might be sufficient to leave the nuts *k* to support the attached object *f*, without replacing them by welds such as *l*, but for most purposes such welds will be required to complete the attachment in a permanent manner, and to secure the object *f* in the strongest possible manner to the plating *a*. The inner ends of the studs *d*, instead of being cut off straight as indicated, might be chamfered or tapered to allow the welding metal to get behind them; or if preferred they might be slightly enlarged with the object of keying them in turn into the welding deposits *g* rather than depending entirely upon the welding together of the metal of the studs and of the deposits *g* to hold them. For most purposes plain ended studs *d*, as indicated, will be sufficient.

In this matter a great deal of thought and consideration was given. Net protection was not very effective against torpedoboat attacks in the North Sea, and the proposition was made to attach to vessels what is known as bulges. These bulges are very ponderous attachments. They come above the waterline and extend some distance below, forming an air space about 8 or 10 feet from the actual ship's bottom at the waterline and below. When a torpedo struck these bulges, it was exploded in passing through the air-tight outer portion and the force of the explosion was taken up or expended on the water that was confined between the sides of the ship and the air-tight space on the outside and the energy was expended in forcing water through hose provided for its

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The Government Needs All the Copper

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is a word that is pretty loosely employed—too often constituting the opinion of the user solely, without reflecting general opinion.

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Expanded Metal Reinforcement for Concrete

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The real adaptability and value of the material as a structural element was discovered in Europe.

THE RESULT IS that American Army Engineers in France to-day are learning something about expanded metal that will be of value to us all when they return.

It is of interest to note that within the past few months the "old guard" of American Expanded Metal Manufacturers have come forward and surprised the world with their ability to manufacture heavier mesh, larger and more perfect sheets than has ever been attempted in any foreign country.

The highest quality Expanded Metal in the world is "made in America."

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escape at the top of the bulge, so that when a ship was struck by a torpedo a fountain would rise as high as the boat, and it proved very effective in the protection of ships. Quite a large number of the ships were provided with protection of this description. It used to take an enormous amount of time to make holes in the armor plate and the difficulty was to make any kind of an attachment or bracket or bulge arrangement to fix the bolts to. Direct welding was tried, with the result that the bolts simply pulled out the armor plates. Then it was attempted to burn holes in the plates, but the diffusion of heat was so great it caused the armor plates to crack where the heat was applied, and that method had to be abandoned.

Finally the suggestion was made to cut a round hole with intensely local heat with a cold electrode. The plan was successfully tried, then tested, and adopted on all that type of protection, as indicated in the sketch.

In conclusion, attention is called to the fact that the results of tensile tests go to show that a welded construction is easily made very much stronger than any form of riveted construction, and that there is hardly any comparison when one considers the necessity of relying on caulking for watertightness.

If this were all there was to the story, one would wonder why there was any hesitation in adopting electric welding to the exclusion of riveting altogether. Unfortunately, it is not the whole story. Tensile tests throw but little light on the value or reliability of welding in ship construction when the stresses are wholly of a complex description in the nature of continuous alternating stress, under which the average weld will break down with stresses very much below their elastic limits, under either tension or compression, a condition which is far more pronounced with some of the systems and materials used in electric welding than others, and particularly under a system permitting anybody to weld anything with anything.

Now that the Classification Societies like Lloyd's, the Electric Welding Committee of the Emergency Fleet Corporation, with the coöperation of the National Research Department, the Engineering Staffs of the great Naval Dockyards and private shipbuilders both in England and America, are carrying on experiments and research, the old order of things will soon go. Only that kind of welding and welding material that is scientifically approved and adopted by them will be permitted, and this under strict rules and regulations; and only then can we expect to see electric welding come into its own, and the positions of riveting and welding reversed in our shipyards.

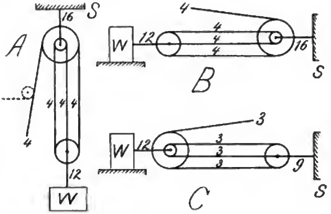
Subsequent discussions will appear in the November issue of the Journal.

TEXT BOOKS VS. PRACTICE

By CARL HERING, Member

THE multiplying pulley, popularly known as the "block and tackle," is usually shown in text books in a vertical position, as in A in the adjoining sketch, the single pulley being attached to the weight W and the double pulley to the support S. For a man pulling downward this may be the best way, as his weight adds to the pulling force.

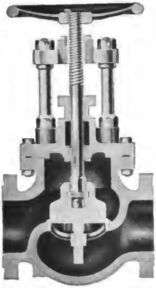
This "rule of thumb" leads one to do the same thing when moving a weight horizontally against friction, or exerting a draw-bar pull, as shown in B. It will be seen, however, that by merely reversing the pulleys, as shown in C, the same weight can be moved with 25 per cent. less force on the pulling rope, or a 33 per cent. greater weight can be moved with the same pulling force.



This reversal of the pulleys will have the same effect in A when the pulling rope is horizontal (shown in dotted lines), as it frequently is in practice. In general, and for all combinations of pulleys, to obtain this advantage, attach the blocks so that the pulling rope leads to the weight and not to the support; or, in other words, pull from the weight and not from the support, text-books notwithstanding.

Others besides the writer may have found this out in practice, but it does not seem to be as generally mentioned in text books as it should be, and may therefore not be commonly known.

On the other hand, the practical man may also commit errors if he follows rules blindly and does not do his own thinking. For instance, in the case shown in B he says, "Stand on the weight while you do the pulling"; in other words, if you are moving a stalled or wrecked automobile, for instance, get on the car yourself. It is true that this will give the same advantages as in C if the man's weight can be assumed to be negligible; but in C no such assumption is necessary, and as his weight generally would add an appreciable load, especially when there is any vertical lifting done, C is always the better way.



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Valves cheaper than **NELSON Valves** can be had. We could make them, too, but we don't. They wouldn't give service up to our standard. They would not have the same character, the same quality of metal, nor would there be the same precision in workmanship and care in testing.

These features determine the worth of a valve. They take **NELSON Valves** out of the "so-much-a-pound" class and make them highly specialized valves that give dependable service.

Study the design of the **NELSON Steel Valve** shown above. Note the extra heavy construction, long curves, large fillets and full area of ports and passages. Note the strongly built yoke and bonnet, with through-bolted flanges and male and female faces to insure perfect alignment.

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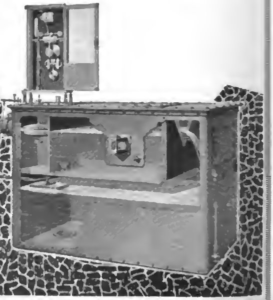

SAFEGUARDING THE FUTURE*

By A. LAWRENCE LOWELL

President, Harvard University

IN matters that do not fall within their immediate experience and observation Americans are idealists. They are apt to imagine a thing as they would like it to be, rather than as it really is. They found it hard to conceive that any nation could want to injure a people that had not injured it; that it could desire to subjugate a peaceful and civilized neighbor. Until 1917 the majority of Americans believed that they could, that they ought, and that they would, keep out of this war. They did not because they could not and ought not.

They could not because war is no longer the affair of those countries alone that engage in it. War to-day is fought with the whole strength of a nation, involving not only all its man power, but all its industry and commerce as well; and with the growth in interdependence of all countries the life of every neutral state is certain to be involved in any war on a large scale. Its interests and its rights are of necessity endangered. Moreover, since war has become so organized that the struggle is between the whole resources, human and material, of the contestants until one or the other is exhausted, it tends to become very passionate, and very regardless of the rights of both belligerents and neutrals in the effort to win. From a war so conducted we could not with honor and safety have kept out if we would; and this our people began to see when Germany declared that she should renew the ruthless use of submarines.

Even, if, by a loss of self-respect and by abandoning the rights of our citizens upon the sea, we could have kept out of war we ought not to have done so; because there is something better in life than selfish ease and material prosperity, better than life itself, and that is the civilization, the moral principles, that make life to us worth living. It is hard to distinguish sharply in our thoughts, as Lincoln did, between the men we are fighting and the principle we are fighting. No one was more determined than Lincoln to crush disunion and destroy slavery, and yet no one had less rancor against the men who had been deluded into the support of these things. Nevertheless those men had to be fought until the principle was settled beyond dispute.

Two principles are arrayed against each other in battle to-day. One is that might makes right, that the fruits of the earth belong to the people who can take them, that there is no moral obligation superior to the welfare of the state, and that the nation strongest in arms is justified in using that strength relentlessly to push aside and trample under foot any people which stands in its path of expansion. The other is that all nations, great and small, are entitled to respect, that all people have a right to justice, and that every being capable of suffering has a claim on the sympathy of man. The struggle is between autocratic, pitiless use of military strength on one side, and liberty, justice and humanity on the other.

We are not fighting for terms, or territorial boundaries between rival powers. If we were they could perhaps be settled without more bloodshed. There is, in fact, a very grave danger from a misunderstanding on this point.

It is not at all improbable that within a few weeks Germany may propose to make peace on terms that appear on their face reasonable and moderate. She may offer to retire from Belgium and France and even to contribute toward the damage suffered, to cede Alsace and Lorraine or leave their future to be decided by plebiscite, to give the Trentino and Trieste to Italy, to relinquish all claim to the captured colonies, to promise some kind of autonomy to the various races in Central and Eastern Europe, and to agree that the sinking of merchant ships by submarines, the dropping of bombs by aeroplanes, the use of poisonous gas, and the other barbarities she has practised, shall not again be permitted in war. Such an offer would be highly seductive, and, if we are not prepared to understand what it means, might well beguile the Allies into a delusive peace. The peace would be delusive, for, unless the principle of militarism is destroyed, the promises would be kept no better than those broken in the past. Autonomy of other races would mean their organization for the strengthening of Germany; until she had control of the resources of a population of two hundred millions for her next war; and the abandonment of her former colonies would be made only with the hope of recoupment in South America on a more favorable occasion. Such a settlement would be a mere truce pending a strife more fierce hereafter. So long as the principle is not overthrown, that he may take who has the power and he may keep who can; so long as predatory militarism is not wholly destroyed, as slavery was destroyed by our Civil War—a result which no one, either North or South, now laments; so long as these results are not attained no lasting peace can be made.

If the upshot of this war is inconclusive the whole world will be preparing for another. The control which within the last century science has given us over the secrets and forces of nature, instead of being used to increase the material comforts and the intellectual and spiritual elevation of mankind will be exploited for the destruction of our fellow men. In the last three years [illegible] have seen to what uses scientific knowledge can be applied in war, and during any temporary truce men of science in all countries will devote much of their thought to making engines more destructive and more deadly for the next struggle, which will be well nigh a war of extermination.

Civilization as we know it has reached a point where it must preclude war or perish by war, and war can be precluded ony by a conquest of the world by a single power, or by an organization of many nations to prevent its recurrence. Germany would, no doubt, be willing to preclude war by subjugating the world, as a result either

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* Address delivered at the National Convention of the League to Enforce Peace, Philadelphia, May 16, 1918.

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of winning this war, which she cannot do, or of better success in the next, an idea that she must not be allowed to entertain. The blood already freely shed by brave men, women and children and that which will yet be poured out, must not have flowed in vain.

The principle of predatory militarism cannot be done away unless mankind has the intelligence, the magnanimity and the determination so to organize itself that justice shall take place of violence and that the predatory state shall be restrained, by force if need be, from wanton resort to arms. No one nation can do this, nor can it be done if the United States stands aloof. We have not met here to discuss the details of such a plan. Clearly it involves a tribunal and other appropriate bodies to which dissensions shall be submitted; force of some kind strong enough to compel resort to the tribunal, or at least to prevent an appeal to arms without a resort to the tribunal; and organs whose duty it shall be to foresee and remove sources of irritation.

We are told that our wise fathers, the founders of our nation, warned us to beware of entangling alliances. They were great because they looked the facts of their day in the face, discerning clearly the signs of their time: and we shall follow their example by doing the same in our day. They made a closer union among the states of this land and thereby prevented war between them, except over a difference of social institutions that could be removed only by battle. The time has come for their heirs to take part in a League of Nations to maintain an enduring peace here and elsewhere. With faith in our purpose, with constancy in effort and sagacity in action, we must finish the work we have begun, until the principle for which we fight stands victorious and unquestioned; and then we must build a structure that, so far as human wisdom can reach, will banish the scourge of war among men.

COAST ARTILLERY SCHOOL FORT MONROE, VA.

Regarding our Heavy (Coast) Artillery:

THIS brief article is written for the information of men interested in the Heavy (Coast) Artillery—particularly those intending to try for a commission. First and foremost any man who hopes to be an officer in the United States Army must be prepared to subject himself to discipline and to work his hardest cheerfully—your enemy is doing just that. Also, your enemy "shoots well," so to outdo him you must be prepared to assimilate all the details you can find of this business of making war.

The Heavy (Coast) Artillery is furnishing and will continue to furnish regiments to man guns of six-inch calibre and above, and all the large howitzers. To furnish the requisite number of officers for these organizations a three months' training course has been established at Fort Monroe. Each Saturday, beginning with September 14, 1918, two hundred men will be taken into the School, and upon successful completion of the work the group will be commissioned. While waiting for your turn to enter the School you will be put in a "reservoir" company and given military training and some instruction in elementary mathematics, to include the solution of plane triangles (trigonometry) and the handling of logarithms. It is expected that each candidate will be in the "reservoir" company only about ten days, so he need not expect to get more than a very hasty review of the above mathematical subjects during that time. It is essential that a candidate have a thorough working knowledge and not merely a smattering in trigonometry and logarithms. The work will begin on the Monday following entrance into the School, and includes work on all of the different guns and howitzers, including drill of the piece in each case.

The course does not necessitate an engineering education or any particular technical training, although an engineering or other technical education is a help in the School and an asset to an officer in the service. Some of the best records have been made by lawyers and business men without previous experience. It requires the proper spirit, proper *mental attitude,* ordinary intelligence, hard work, and a "full day's work each day." The idea of those in command is twofold—first, to have officers with the ability to command troops; second, to have those officers able to make hits with their batteries.

The Heavy (Coast) Artillery has the equipment and the personnel to handle this School. Those in charge have been on the Western Front and know what should be taught. The School has been in operation continuously since May, 1917. Each month instructors are sent back from the American Expeditionary Force to keep the work up to the standard demanded by General Pershing. The land target range, under the supervision of the Commanding General of the Coast Artillery Training Center, is located at Camp Eustis, on the James River, near at hand, so that each graduating group can receive practical instruction in firing before going to their organizations.

As General March, the Chief of Staff, has publicly announced that the American Army in France will number 4,000,000 men next year, the Heavy (Coast) Artillery will have to supply its share. Therefore the Coast Artillery School is prepared to consider applications from any citizen of the United States who is registered for military service. The camp does not agree to accept every application—and does not in any sense guarantee a commission to those who are accepted. It is up to the man himself, with all the help we can give him, to make good.

For information write to:

The Commandant, Coast Artillery School,
Fort Monroe, Virginia.
Attention of Communication Officer.

BY ORDER OF LIEUTENANT-COLONEL WELSHIMER:
C. L. KILBURN,
Captain, C. A. C., Secretary.

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Correctly designed for maximum strength with light weight. Guaranteed for minimum belt slip, minimum air resistance, double belt service, rim speeds up to 6000 feet per minute.

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The steel working parts and all parts of the hoist subject to strains are three and one-half times as strong as need be. Sudden shocks with their attendant damaging strains on the hoist are prevented by the **LOOP Hand Chain GUIDE**.

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COMMITTEE ON PAPERS

LEWIS H. KENNEY, CHAIRMAN

REGULAR MEETING

At Witherspoon Hall, Tuesday, October 15, 1918, 8.15 P. M.

Mr. Frederick K. Morris, of Columbia University, will present an address entitled **"The Fourth Year."**

Illustrated with motion pictures and lantern slides.

Members of Affiliated Societies are cordially invited to attend.

Members of the Club and Affiliated Societies are privileged to invite ladies.

Mr. Morris will present a brief review of the events that led up to the situation that existed at the beginning of 1918. Then, more fully, the 1918 campaign will be considered, the topography of the country, the strategy devised by the Germans in each of their great drives, and the manner in which these attacks were met; what places the Allies yielded, which lines and places they stubbornly held, the situation when the attack was renewed along the Marne salient on July 16, and the series of counter-offensive strokes by which the Allies regained and held the initiative. No one should offer prophecies in this war; but in their stead, the strategic possibilities of some of the great strongholds that now lie before our armies will be considered.

TUESDAY NOON LUNCHEONS

The Committee on Papers desire that as many of the members as can conveniently do so arrange to attend the Tuesday Noon Luncheons. We are arranging these Luncheons with a view to providing informal addresses on subjects which will interest the membership. Arrangements are being made to publish some of these addresses in the Journal.

Opportunity is offered at these Luncheons for the President to present matters of interest to the membership, and it is the intention of the Committee that they also serve as a forum for the membership.

The following schedule of speakers has been arranged:

October 1	Mr. John H. Mason, President, Commercial Trust Company:—**"Our Privilege to Help Win the War."**
October 8	Mr. Thornton Lewis:—**"Some of America's Explosive Plants."**
October 15	Sydney Young, Esq.:—**"America and the War."**
October 22	Mr. H. A. Hornor, Emergency Fleet Corporation:—**"The Animal Engineer."**
October 29	Dr. Henry Leffmann:—**"The Chemist and the Chemical Engineer in Modern Warfare."**
November 5	Maj.-Gen. L. W. T. Waller, U. S. M. C.:—**"The United States Marine Corps."**
November 12	Philip Francis Nowlan:—**"Sales Engineering."**
November 19	Mr. Geo. S. Webster, Director, Department Wharves, Docks and Ferries:—**"The Port of Philadelphia."**

COMMITTEE ON MEMBERSHIP

PAUL SPENCER, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before October 7 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

GEORGE ELLWOOD BURTON,
1617 East Berks Street, Philadelphia, Pa.
Assistant Chief Engineer, Niles-Bement-Pond Company.
Proposed by John G. Maguire and Linn O. Morrow.

ANDREW M. CHESNEY,
C/o Canadian Exposives Limited, Beloeil Sta., Que., Canada.
Assistant Works Manager, Canadian Explosives Limited.
Proposed by Jacob L. Warner and Curtis C. Meigs.

J. PARKER B. FISKE,
1317 Spruce Street, Philadelphia, Pa.
Engineer and Manager, V. P. Fiske & Co., Inc., Boston, Mass.
Proposed by Clayton W. Pike and H. F. Sanville.

ISAAC STANLEY WALKER,
594 Drexel Building, Philadelphia, Pa.
General Manager, New Chester Water Co. and Allied Companies.
Proposed by R. R. Fernow and Daniel A. McCrudden.

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The Government now requests,
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If you are a purchaser of pig tin, or of tin containing alloys of any description, write us and we will gladly place at your disposal our experience of thirty-eight years, and advise you if, in your case, less tin can be used.

In making our recommendations, we shall naturally bear in mind that it is necessary at least to maintain your service efficiency. It may even be possible to make a recommendation to you which will not only conserve tin but increase the efficiency of your alloy, and save you money besides. We have found it possible to do this in many instances.

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It is necessary to start *now* to stabilize business for "after the war." Markets must be sustained and developed. New markets created. This means *advertising*, and best of all, *illustrated advertising*. Whatever problems you may have in presenting your proposition graphically to the public we can probably help you solve them.

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Food and Money

Play as important a part in the Teutonic struggle that is taking place on the battle fields of Europe as any other element that enters into it. You have been advised and begged to save your food, and you should do no less with your money. Every day that you save, provided you invest it in some Governmental loan, adds to your effort in bringing the War to a successful issue, and while you are saving your dollars, you need a bank account, and convenience for the saving of time as much as anything else, so when you think of opening one come to the

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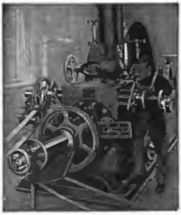

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SECRETARY'S NOTICES

A REGULAR MEETING of the Club will be held **Tuesday evening, October 15, 1918, at 8.15 o'clock, at Witherspoon Hall.**

H. A. STOCKLY,
Secretary.

ABSTRACT OF MINUTES

of the Special Meeting of the Club held Monday, August 12, 1918:

The meeting was called to order by President Stevens at 12.30 P.M., and, due to the lack of a quorum, was recessed until Tuesday, August 13, at 12.30 P.M.

ABSTRACT OF MINUTES

of the Reconvened Special Business Meeting of the Club held Tuesday, August 13, 1918:

The meeting was called to order by President Stevens at 12.30 P.M., and, due to the lack of a quorum, was recessed until Tuesday, August 20, at 12.30 P.M.

ABSTRACT OF MINUTES

of the Reconvened Special Business Meeting of the Club held Tuesday, August 20, 1918:

The meeting was called to order by President Stevens at 12.30 P.M. Fifty-five voting members, being more than sufficient to constitute a quorum, were present.

The resolutions approved by the Board (see Abstract of Minutes of Board of Directors' meeting of August 6, 1918), authorizing the Club to raise funds as therein prescribed, were unanimously adopted, and the Board instructed to take any or all necessary steps to carry out the provisions of these resolutions.

The meeting adjourned at 1 P.M.

LETTER BALLOT OF THE BOARD OF DIRECTORS

Following is a list of actions taken by letter ballot of the Board of Directors, as of September 17, 1918:

Ballots were received from the following: President Stevens, Vice-Presidents Andrews and Wagner, Treasurer Kenney, Past President Carter, Directors Gant, Long, Spencer, Swaab, James, Lauer, Quimby, Lee, Terrell, Newkirk, Murphy, Barr and Douglas.

The following members were elected to active membership:

Sydney Buckley
Lewis G. Gillett
Charles D. Hickman
Ray L. Somers

Mr. F. B. O'Connor was transferred from Junior to Active membership.

Announcement has been received of the death, on September 10, 1918, of Mr. Walter M. Stein, who was elected to Active membership December 21, 1915.

The Philadelphia Section of the Association of Iron and Steel Electrical Engineers, which has a membership of about 114, was elected to affiliation with the Engineers' Club, in accordance with Article XI, Section 2, of the By-Laws.

ABSTRACT OF MINUTES

of the Special Meeting of the Engineers' Club, held Monday, September 16, 1918, at the Bellevue-Stratford.

The meeting, which was a Joint Meeting of the Engineers' Club, Philadelphia Section of the American Institute of Electrical Engineers, and Philadelphia Section of the Association of Iron and Steel Electrical Engineers, was called to order by Mr. J. Franklin Stevens, at 8 P.M. About 400 were in attendance, including representatives from the principal shipyards on the Pacific and Atlantic coasts, and many industrial plants throughout the United States.

President Stevens opened the meeting with the following address of welcome:

> I wish on behalf of the Engineers of Philadelphia to greet you and bid you welcome.
>
> We engineers of Philadelphia feel honored that you have chosen our city for this important meeting, but also feel that your choice was logical, for here was born the inventor of electric welding, here electric welding was first put into practice on a large commercial scale, and here to-day we find its greatest and most extensive application in our great Delaware River shipyards.
>
> This meeting is held under the joint auspices of the Engineers' Club of Philadelphia, the Philadelphia Section of the American Institute of Electrical Engineers and the Philadelphia Section of the Association of Iron and Steel Electrical Engineers; and I am calling it to order as the President of the Engineers' Club, the senior of the three societies.
>
> By and through this meeting we testify to our interest in and pledge our assistance to the Emergency Fleet Corporation and all other agencies of the Government engaged in work of an engineering character.
>
> As we have before us a program which will fully occupy our time and a discussion which, I am sure, will prove both interesting and profitable, I will not infringe on your time by extending my opening remarks, but will proceed to the business of the evening.

President Stevens introduced, as Chairman of the meeting, Professor C. A. Adams, President of the American Institute of Electrical Engineers, Chairman of the Electric Welding Committee of the Emergency Fleet Corporation, and Chairman of the Electrical Section of the National Engineering Council.

Professor Adams presented Mr. H. A. Horner, Head of the Electric Welding Branch of the Emergency Fleet Corporation, who delivered a paper on "Electric Welding—A New Industry," illustrated with lantern slides and a demonstration of arc welding. The paper was discussed by Messrs. Lincoln, Talbot, Frees, Howslag, Wanamaker, Reed, Bigelow, Poole, Stevens, Hilton, Jasper Cox, Allison, Gravell, Ewerdz, Armstrong, Kincade, Dudley and Snyder.

The meeting adjourned at 10.30 P.M.

H. A. STOCKLY,
Secretary.

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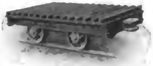

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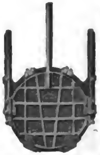

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COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, CHAIRMAN

ADDITIONS AND CORRECTIONS TO HONOR ROLL PUBLISHED IN THE SEPTEMBER JOURNAL

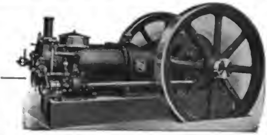
ABBEY, J. F.	Lieutenant	4th Student Co., Eng. Off. Training School	Camp Humphreys, Va.
ALLEN, J. G.	1st Lieutenant	Co. "D," 56th Infantry	American Expeditionary Forces, via New York
ALTHOUSE, A. K.		Co. 5, Engineer Officers' Training School	Camp Humphreys, Va
BELL, F. F.	Captain	Air Service Flying School	Gerstner Field, La.
BROWN, W. L.			331 Temple St., New Haven, Conn.
CHANCE, T. M.	Major	Chemical Warfare Service, N. A.	Edgewood Arsenal, Baltimore, Md.
COLEMAN, G. K.		3rd Training Company, C. A. C.	Fort Monroe, Va.
CORSON, W. C.		A. & M. College	College Station, Texas
DERBY, C. F.	Captain	Ordnance Department	Aberdeen Proving Ground, Md.
EAGAN, G. A.	Captain	Ordnance Department	
ESSICK, P. J., JR.	Lieutenant	Co "A," 5th Infantry	Camp Beauregard, Alexandria, La.
FRANK, A.	2nd Lieutenant	540 Service Battalion, Engineers	Camp Humphreys, Va.
GALLOWAY, J. W.	Lieutenant	Engineers, U. S. A.	4075 Market St., Philadelphia
GOODWIN, H., JR.	Lieutenant	U. S. Naval Reserve	Office of Chief of Naval Operations, 1729 G St., Washington, D. C.
HINTON, J. C.	1st Lieutenant	Engineers Corps, U. S. A.	Camp Humphreys, Va.
HULME, N.	1st Lieutenant	458 Engineer Truck Co., Motor Reception Park	A. P. O. 760, American Expeditionary Forces, via New York
KELLOGG, L. P.		Officers' Training School, Motor Transportation Service	Camp Joseph E. Johnston, Florida
LAWSON, W.	Captain	Supply Co., 109th Infantry	American Expeditionary Forces, via New York
McCRACKEN, S. L.			Camp Lee, Va.
McCAUSLAND, J. R.	Master Engineer	R. T. O. Sanenay, Base 701	American Expeditionary Forces, via New York
MAHAN, J. H.	Lieutenant	Signal Corps	Gerstner Field, Lake Charles, La.
MILLER, J. B. R.	1st Lieutenant	Chemical Warfare Service	Camp Humphreys, Va.
RADER, H.	1st Lieutenant	Quartermaster's Corps	1422 Massachusetts Ave. N. W., Washington, D. C.
RITCHIE, J. M.	Major	Motor Transportation Corps	Washington, D. C.
SMITH, GODFREY D.	Lieutenant	112th Infantry	American Expeditionary Forces, via New York
SMITH, XANTHUS R.	1st Lieutenant	Ordnance Department, U. S. A.	Winchester Repeating Arms Co., New Haven, Conn.
STONE, H. B.		Central Machine Gun Officers' Training Camp	Camp Hancock, Ga.
THOMSON, H. A.	1st Lieutenant	In care of Utilities Officer	Camp Hancock, Ga.
UHLER, W. D.	Lieutenant Colonel	Motor Transportation Corps	Washington, D. C.
WHEELER, R. C.	Captain	Port Utilities Officer	Newport News, Va.

JUNIOR SECTION

WILMER Z. KLINE, Chairman

The first meeting this year will be held on Tuesday evening, October 8th, at the Club House. No formal paper will be presented, but a very prominent speaker will talk on a subject of general interest. There will be plenty of smokes and refreshments, and as the affair is intended to promote good-fellowship and sociability, all members are urged to be present and to bring a friend or two with them.

The November meeting will be a joint meeting with the Philadelphia Radio-Engineering Society and will be held in the Club House. Mr. C. L. Ballantine will present a paper, "The Theory and Operation of the Electron Relay with particular reference to Electric Communication."



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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

W. F. JAMES, *Chairman*

E. B. TUTTLE, *Secretary*
Bell Telephone Building
1631 Arch Street.

OCTOBER MEETING

The October Meeting will be a National Meeting. It will be held in Philadelphia, October 11th, and will consist of afternoon and evening sessions and a boat trip on the Delaware River.

The afternoon session will be devoted to the discussion of "mine" problems, solved electrically, and the evening session to Engineering Research.

It is expected that this will be a joint meeting with the American Physical Society, who will continue their session Saturday.

The meetings on Friday afternoon and evening, October 11th, will be in the Bellevue-Stratford Hotel, and an informal dinner will fill the time between the afternoon and evening sessions.

Members of the Engineers' Club and affiliated societies are welcome to attend the meetings and the dinner.

PHILADELPHIA SECTION
ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS

D. M. PETTY, *Chairman*

LINN O. MORROW, *Secretary*
19th and Hamilton Streets

The first monthly meeting of the Philadelphia Section of the Association of Iron & Steel Electrical Engineers, season of 1918-1919, will be held on Saturday, October 5, 1918, at the Engineers' Club, 1317 Spruce Street.

"Electric Furnaces" is the subject of the evening.

Mr. George H. Schaeffer, Electrical Engineer of the Carpenter Steel Co., Reading, Pa., will present the electrical side of the subject, and Mr. L. B. Lindemuth, Superintendent of the Crucible and Electric Furnace Departments of the Bethlehem Steel Co., South Bethlehem, Pa., will present a paper on the Electric Furnace from the metallurgical standpoint.

The meeting will start promptly at 8 P.M., and wil be preceded by an informal get-acquainted dinner, starting promptly at 6 P.M.

EASTERN PENNSYLVANIA CHAPTER
AMERICAN SOCIETY HEATING AND VENTILATING ENGINEERS

E. T. MURPHY, *Chairman*

A. P. GOLDSMITH, *Secretary*
1519 N. Broad St.

The Eastern Pennsylvania Chapter of the American Society of Heating and Ventilating Engineers will resume their regular monthly meetings on Thursday evening, October 10th, at 8 o'clock, at the Manufacturers' Club, with a talk by Mr. Charles Haynes, of the Haynes Selling Co.

The subject of his discourse will be, "Coal Conservation," which, in the face of the fuel situation and coming cold weather, should be both timely and welcome.

Mr. Haynes is an authority on this subject and what he has to say is always interesting to his hearers.

A large attendance at this opening meeting is anticipated.

POSITIONS OPEN

Wanted: Young man as Engineer of Tests, to take in steam boilers, engines, turbines, electrical equipment, gas producers and furnaces. Should be technical graduate. Practical experience not necessary if applicant has technical training along this line. Apply No. 246-A, Engineers' Club.

Wanted: Construction Engineer—familiar with electrical substation construction and wiring. Work is in connection with electric heat treating and melting furnaces. (The work comes under aircraft and emergency fleet classification.) Apply No. 248-A, Engineers' Club.

POSITION WANTED

Designing and production engineer wishes permanent position with manufacturing firm. At present employed as superintendent of sheet metal plant. Age 35; married. Apply No. 222, Engineers' Club.

Pag. of.

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-11 NOVEMBER, 1918 NO. 168

ELECTRIC WELDING AS APPLIED TO STEEL SHIP CONSTRUCTION

A series of discussions held under the auspices of the Electric Welding Branch of the Education and Training Section of the U. S. Shipping Board, Emergency Fleet Corporation.

Fifth Discussion

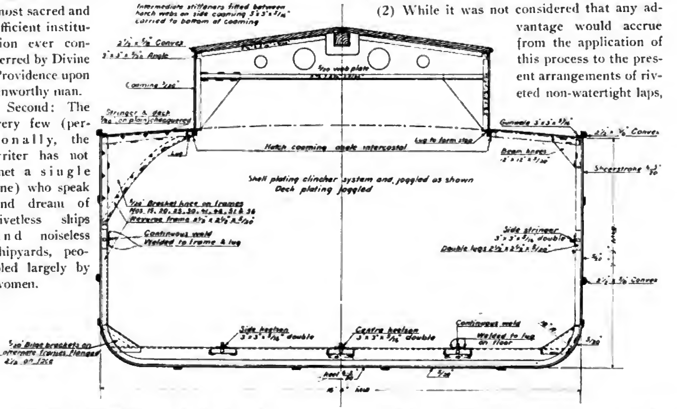
A COMPARISON BETWEEN AMERICAN AND BRITISH PRACTICE IN ELECTRIC WELDING*

By COMMANDER S. V. GOODALL
Naval Constructor, British Navy

WITH respect to their attitude towards electric welding the various practical shipbuilders in America and Great Britain may be divided, roughly, into three classes.

First: The very few who speak as though a riveted joint were the most sacred and efficient institution ever conferred by Divine Providence upon unworthy man.

Second: The very few (personally, the writer has not met a single one) who speak and dream of rivetless ships and noiseless shipyards, peopled largely by women.


Intermediate stiffeners fitted between hatch webs on side coaming 3"x3"x5/16" carried to bottom of coaming
2½" x 5/8" Convex
3"x3"x5/16" Angle
5/20 web plate
Coaming 5/20"
Stringer & deck 5/20" on plain chequered
Lug
Hatch coaming angle intercostal
Lug to form step
Gunwale 3"x3"x5/16"
2½" x 5/8" Convex
Beam knees 12" x 12" x 5/20"
Sheerstrake 6/20"
Shell plating clincher system and joggled as shown
Deck plating joggled
5/20" Bracket knee on frames Nos. 15, 20, 25, 30, 41, 46, 51 & 56
Reverse frame 2½" x 2½" x 5/20"
Continuous weld
Welded to frame & lug
Side stringer 3"x3"x5/16" double
Double lugs 2½"x2½"x5/20"
5/20"
2½" x 5/8" Convex
Side keelson 3"x3"x5/16" double
Centre keelson 3"x3"x5/16" double
Continuous weld
Welded to lug on floor
5/20" Bilge brackets on alternate frames flanged 2½" on face
5/20"
keel 6/20"
5/20"
16' 4" mld

SKETCH 1.—MIDSHIP SECTION OF ARC-WELDED BARGE. LENGTH, 125′ 9″. BREADTH, 16′ 4″. DEPTH MOULDED, 7′ 9″. DEADWEIGHT CAPACITY, 200 TONS. FRAMES, 2½″ X 2½″ X ¼″ ANGLES. FLOORS, 7″ X 3½″ X 5/16″ ANGLES. SHELL AND DECK PLATING, 5/20″ TO 6/20″. SHELL PLATING JOGGLED AND LAPPED AT EDGES, FLUSH BUTTS WITH STRAPS. DECK PLATING STRAPPED BUTTS.

Finally, there is the great majority of shipbuilders who are too busy to develop new, though promising, methods, but who will employ any new process as soon as they are convinced that this is worth doing. To these are commended the matter and spirit of this paper, and their attention called to the attitude of the British Admiralty, the United States Navy Department, Lloyd's and the American Bureau.

In October, 1917, not a very recent date, considering the rate at which scientific matters now progress, the British Admiralty called a conference of some of the most experienced constructors from various navy yards, and some of their recommendations were as follows:

(1) Although the covered electrode, or quasi-arc, process of electric welding could not be advantageously adopted in all cases as a substitute for the present process of drilling, riveting, caulking, etc., yet its use would undoubtedly result in a great reduction in the labor involved in such processes.

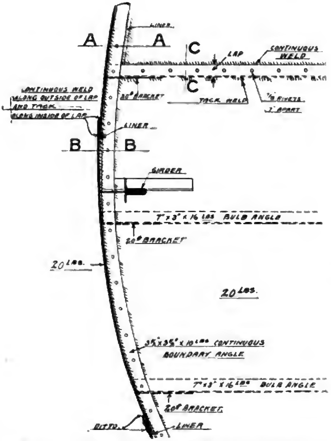
(2) While it was not considered that any advantage would accrue from the application of this process to the present arrangements of riveted non-watertight laps,

---

* Delivered in the auditorium of the Engineers Club of Philadelphia, Wednesday, July 31, 1918.

butts, stiffeners, etc., all watertight work of this nature could probably be well and efficiently performed with economy in labor, by increasing the rivet spacing as much as possible, consistent with the proper closing of the work, and supplementing this by covered electrode arc welding to meet the requirements for strength and watertightness.

(3) By this system the process of water-testing would be greatly facilitated, with a corresponding saving in time and labor.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A
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LAP
CONTINUOUS WELD
C
CONTINUOUS WELD ALONG OUTSIDE OF LAP AND TACK ALONG INSIDE OF LAP
20# BRACKET
TACK WELD
7/8 RIVETS 3" APART
LINER
B
B
GIRDER
7" x 3" x 16 LBS BULB ANGLE
20# BRACKET
20 LBS.
20 LBS.
3½" x 3½" x 10 LBS CONTINUOUS BOUNDARY ANGLE
7" x 3" x 16 LBS BULB ANGLE
20# BRACKET
DITTO
LINER

SKETCH 2.—CLINKER SYSTEM—SECTION SHOWING WELDED SHELL PLATING.

The United States Navy Department, Lloyd's, and the American Bureau have sanctioned the use of electric welding for angle staples, plate staples, and similar watertight work, in addition to its general use on such work as securing fittings, etc., to watertight bulkheads and decks, whereby not only are time and labor saved, but better watertightness is obtained.

Passing now to specific examples of electric welding, we will first speak of the American practice. It will be quickly seen that American and British practice differ very considerably. In Great Britain the process invariably used is the quasi-arc, since British engineers have found the flux-covered electrode and this system the best they have so far tried. We have, however, an open mind and a desire to reduce costs, so that any other system will find a fair field and no favor.

AMERICAN WELDING PRACTICE

The following extracts from letters which the writer has received from some of the leading shipyards in America may be illustrative of the typical jobs to which electric welding is applied in the United States:

NEWPORT NEWS:

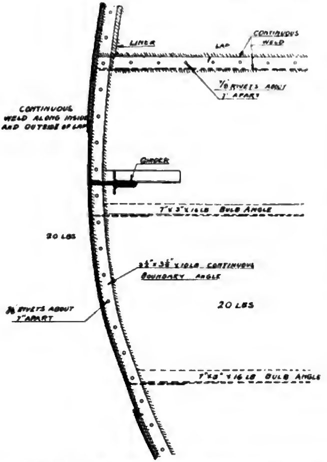
> We have been using electric welding for the past four years, and although it has been developed to quite an extent, we feel that much more work can be done by this method, as soon as the various inspectors realize the full value of electric welding and will allow its more extensive use.
>
> Referring to your request for facts relative to the saving of time, labor and money which have been effected by the adoption of electric welding: The developments in connection with electric welding have been so rapid and the uses to which it has been put have been so extensive that we have not attempted to obtain comparative costs between this and other methods, having contented ourselves with the very evident economy obtained by the electric method.
>
> We are not in sympathy with the completely welded ship idea, but believe there is a happy medium limiting the extent of the electric welding, which, to a great degree, is determined by the personnel of the welding department and the experience to those who outline the work to be done by the electric method.

BETHLEHEM SHIPBUILDING CORPORATION:

> We are in the yard welding all the non-strength clips and fittings to the destroyers, such as furniture clips, cocoa-matting strips, backing strips for sheathing, shelf clips, etc. The welding of these small jobs eliminates the work of punching the clips, laying off for drilling, bolting up and finally riveting. This work, it will be noted, is very much scattered, and therefore comes under the shipyard term of "odd work." Odd work is necessarily very costly.
>
> The above jobs are now being done at a very much reduced cost and very much less time. * * *

THE PANAMA CANAL, DEPARTMENT OF OPERATION AND MAINTENANCE:

> It may seem like a strange assertion to state that we do not employ anglesmiths in the shops, but we do not require them—all our angles are welded together by the oxy-acetylene- and electric-welding processes.
>
> Frames, staples, webs, brackets, sheet-iron and steel boxes, leaky joints on ships' bottoms, plates of tanks, pipes and fractures in all kinds of ship machinery are welded; in fact, electric welding, oxy-acetylene welding and cutting and oxy-hydrogen cutting are so extensively used in ship work that they have become practically indispensable in their use to the Mechanical Division on account of the big saving in time, labor and cost.
>
> From our own experience and through keeping in touch with this line of work being carried on in the industrial establishments in the States and elsewhere, we have come to the conclusion that oxy-acetylene or electric arc and spot welding in their present stage of development cannot supplant all watertight ship work that is now being done by riveting, but it will be only a matter of time, due to the rapid strides made in the development of autogenous welding outfits, when all obstacles in this line of work will be overcome.


LINER
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7/8" RIVETS ABOUT 7" APART
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7" x 3" x 16 LB BULB ANGLE
20 LBS
3½" x 3½" x 10 LB CONTINUOUS BOUNDARY ANGLE
20 LBS
7/8 RIVETS ABOUT 7" APART
7" x 3" x 16 LB BULB ANGLE

SKETCH 3.—RAISED AND SUNKEN SYSTEM AND CONTINUOUS WELDS. TRANSVERSE ELEVATION SHOWING SHELL AND W. T. BULKHEAD PLATING AND THEIR CONNECTIONS.

THE SUBMARINE BOAT CORPORATION:

> We are welding approximately sixty frames on each ship in addition to doing a great deal of miscellaneous welding in connection with outfitting of ships. The welding in outfitting has not yet fully developed. By this, I mean that we are daily finding additional places where electric welding can be used to advantage, and we are strongly inclined to push the use of welding to the limit, for the reason that we find it considerably cheaper than angle-smithing work for frames, and considerably cheaper and faster than drilling and tapping deck beams and bulkheads for attaching miscellaneous small brackets.

THE NORFOLK NAVY YARD:

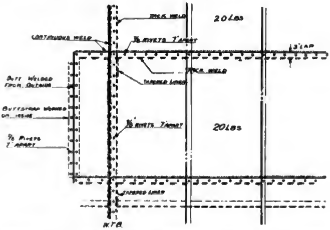
In the first discussion of this series, the work being done at the Norfolk Navy Yard, where an electrically welded battle-practice target is under construction, has been described by Naval Constructor H. G. Knox, U. S. N., and will not be taken up in detail in this paper. It may be well to note, however, that this structure is composed of simple plate work with no liners and no curved plates, and that while it is a good design to start on, it has, however, because of lack of curved surfaces, the disadvantage that it does not, in this particular, apply to the conditions existing in an ordinary ship—particularly to a merchant ship.

The joint between the flat keel and side keel plates and the joint for attaching plates at right angles appear to the writer to be amply strong and likely to remain watertight longer than a riveted joint. The welds, however, are heavy and, according to British experiments, they will be extremely costly, compared to riveting. Further, on account of inaccessibility, it would appear that good welding would be difficult to obtain.

On the other hand, this design will serve to demonstrate whether it is easier to work plates transversely or longitudinally, and whether the difficulties anticipated from unusual shrinkage are the same in both cases. When complete, this structure will not be subjected to such a variety of complex live loads as a ship, but at various times in its career it will be subjected to considerable shock, so that valuable experience will be obtained.

SPOT WELDING

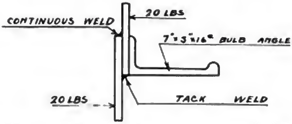
Before leaving American practice, a few words should be said about spot welding. Professor Comfort Adams has given his opinion as follows:



SKETCH 4.—CLINKER SYSTEM—EXPANSION OF SHELL PLATING SHOWING LAPS AND BUTTS.

> Electric spot-welded joints, properly made, are stronger than riveted joints.
>
> The total labor required for the welding of a given number of spots is about one-quarter to one-fifth of that required for the same number of rivets.
>
> The only fear that has been expressed by anyone in connection with the application of spot welding to shipbuilding is that crystallization may develop as a result of the ship's vibration. It is the opinion, however, of some very able shipbuilders that the intensity of the vibrational stress in the structure of the ship is not sufficient to warrant this fear. In any case, it is hoped to plan such vibrational tests, in connection with the work of this sub-committee, as to clear up this point.
>
> Everyone with whom I have talked on this subject agrees that the probable gain by the substitution of spot-welded for riveted joints in shipbuilding is so great as to warrant the expenditure of every effort to give it a thorough trial.

The work done at *Hog Island* was described by Mr. Anderton in the October Journal of the Engineers' Club of Philadelphia.



SKETCH 5.—CLINKER SYSTEM—SECTION AT C-C SHOWING METHOD OF WELDING AT LAP OF BULK^{D} PLATING.

Shipbuilders in Great Britain would be very glad to profit from American experience. They certainly fear crystallization, the possibility of a poor joint through some defect between the faying surfaces, and also that the joint may ultimately fail through one weld being poor or taking an undue share of the load.

BRITISH WELDING PRACTICE

Passing now to British practice, and taking up first the question of repairs, the following typical instances are illustrative of the very broad field to which electric arc-welding has been applied in Great Britain, with great savings in both time and expense:

In one case, a ship with a number of fractures in the bottom plating was repaired by welding up the cracks after they had been "veed." This work was accomplished in sixteen hours, whereas the renewal of plating would have involved the loss of that ship's services for many days.

ELECTRICALLY WELDED CAST STEEL STEM WHICH HAD BEEN BROKEN INTO FIVE PIECES.

In another case, a steel stem casting broken into five pieces by collision was repaired in seven days. To obtain a new casting would have required four to five months.

In other cases, ships which were experiencing trouble through leaky butts straps were repaired by welding a thin strip over the joint and a satisfactory result obtained. To fit a double strap outside the ship (the practice before electric welding was introduced) would have involved much time and labor and would not have been very satisfactory, causing a poor surface and a poor joint.

The reinforcement of badly pitted plates is another of the uses to which electric welding has been applied in ship repair during the present war.

ELECTRICALLY WELDED BARGE*

The construction of this ship (see sketch No. 1) is similar to that of a riveted ship. The plates were bolted up when the parts were assembled, and after welding the bolts were removed and replaced by plugs, which were welded up flush with the plating.

The plates, etc., are comparatively light and easy to weld, the only difficulty in the thin plates being that the plate may be grooved along the weld if the operator is not particularly careful.

The type of joint used in this construction was chosen with the purpose of making as much as possible of the welding horizontal, so as to render good work more easily obtainable.

EXPERIMENTS DESIGNED TO SHOW THE RELATIVE MERITS OF WELDED AND RIVETED SHIP CONSTRUCTION

We now come to two of the most interesting applications of electric welding to ship construction so far attempted in Great Britain. The two ships, sections of which are shown in sketches Nos. 2 and 3, had a portion of the side plating—on one side of each vessel only—electrically welded. The other side of each ship was riveted in the usual manner. In one case, sketches Nos. 4, 5, 6, and 7, the plating was worked on the clinker system; in the other, sketches Nos. 8, 9, 10, and 11, on the raised and sunken system. Ordinary ship construction was followed in both cases, and although the sketches do not show the most curved portion, the curvature of the shell is very evident. The shape of the shell and the restricted space between it and the longitudinal bulkhead rendered the work extremely difficult, and under more straightforward conditions better results should be obtained.

THE CLINKER SYSTEM

Referring first to the clinker system, it will be noted (see sketch No. 2) that the joint of the lapped edge is horizontal and made in the open by a continuous weld. Rivets with non-watertight spacing were worked and an intermittent weld applied to the lower edge. If well made, such a joint is quite as good and almost as cheap as a double-riveted lap. The joints of the bulkhead plates are made similarly. Attention is called to the bulb stiffeners at CC and to the joints at BB and AA as illustrative of the difficulties that arise in actual ship construction such as this.

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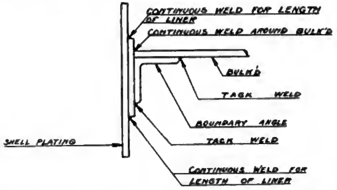
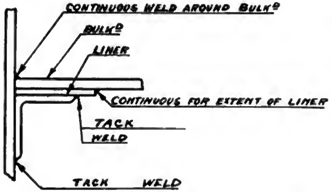
* For particulars relative to this work the writer is indebted to Captain Caldwell and the Quasi-Arc Company.


CONTINUOUS WELD FOR LENGTH OF LINER
CONTINUOUS WELD AROUND BULK'D
BULK'D
TACK WELD
BOUNDARY ANGLE
TACK WELD
SHELL PLATING
CONTINUOUS WELD FOR LENGTH OF LINER

SKETCH 6.—CLINKER SYSTEM—SECTION AT B-B SHOWING METHOD OF WELDING TAPERED LINER AT LAP OF SHELL PLATING.

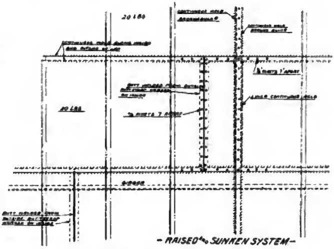
In sketch No. 4 the butts of the shell plating are indicated. The joints are between frames and the strap, which is 5⅜ inches wide, is worked on the inside, connected by rivets with non-watertight spacing, and the butt welded from the outside. Such a joint, if well made, is quite as strong as a double-riveted single-butt strap, is slightly cheaper, and remains watertight at greater loads—an important point often overlooked.


CONTINUOUS WELD AROUND BULK^D
BULK^D
LINER
CONTINUOUS FOR EXTENT OF LINER
TACK
WELD
TACK WELD

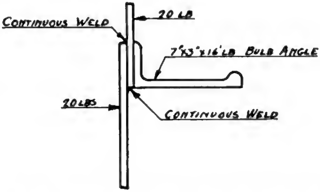
SKETCH 7.—CLINKER SYSTEM—SECTION AT AA SHOWING METHOD OF WELDING TAPERED LINER AT LAP OF BULK^D.

Sketch No. 5 shows a section through the bulkhead lap. It is of interest, as it somewhat resembles a shell plate joint at a frame.

The additional welded work necessary where a tapered liner is fitted in order that the bulkhead angle may pass fairly from one strake of shell plating to the other is shown in sketch No. 6. Similar work is shown in sketch No. 7, where the bulkhead angle passes from one strake of bulkhead plating to another. While in these cases there is considerable difficult welding, such work is less likely to give trouble by leakage than ordinary riveted and caulked liners and joints. In this sketch it may be noted that in the connection of the bulkhead to the shell the boundary bar is fastened by rivets with non-watertight spacing, a continuous weld being worked along the keel and intermittent welds at the toes of the bar at the bulkhead and shell plating. This is an interesting comparison with American ideas in regard to right-angle connections. Incidentally, it may be added that the ordinary frames are riveted to the shell.



SKETCH 8.—RAISED AND SUNKEN SYSTEM—EXPANSION OF SHEL PLATING SHOWING LAPS AND BUTTS.

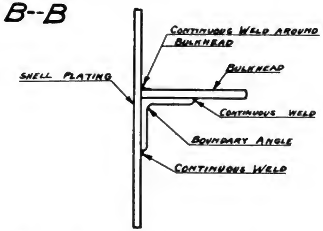


SKETCH 9.—RAISED AND SUNKEN SYSTEM AND CONTINUOUS WELDS—C-C SECTION SHOWING METHOD OF WELDING AT LAP OF BULK^D PLATING.

THE RAISED AND SUNKEN SYSTEM

The remaining sketches show similar work on the second ship, plated on the raised and sunken system. Note, in sketch No. 3, that, in addition to this difference, the bulkhead boundary bar has a continuous weld at the toe, both at the shell and the bulkhead. This work was done for comparison, but it is hoped that experience on service will show such extra work unnecessary.

Sketch No. 8 shows the riveted edges and butts. There is a continuous weld on the outside and inside of the laps, whereas in the other ship (sketch No. 4) there was an intermittent weld on the inside. Further, on account of the strake being a raised one, the liner extends the whole width instead of tapering, so that additional welding is involved.



SKETCH 10.—RAISED AND SUNKEN SYSTEM AND CONTINUOUS WELDS. SECTION SHOWING METHOD OF WELDING BULK^D TO SHELL PLATING.

Sketch No. 9 shows the welding at a lap of bulkhead plating, and is similar to the work (see sketch No. 5) on the clinker system ship.

Sketch No. 10 shows the bulkhead boundary bar, with its three continuous welds instead of one continuous weld at the heel and two intermittent welds at the toes, as shown in sketch No. 7.

Sketch No. 11 shows the considerable welding where the boundary bar passes over the lap of the bulkhead plating and a raised strake of shell plating, necessitating two sets of liners.

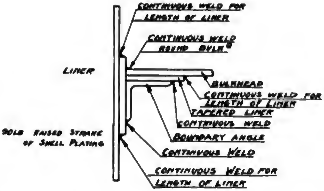
SUMMARY OF RESULTS OBTAINED

The following interesting experience has been obtained from this work:

In the case of the clinker system, where there was no overhead work on the outside of the ship, the plating was practically watertight on the first test; but in the other ship, on water-testing, the laps which had been overhead-welded on the outside leaked, and difficulty was experienced in overcoming the leaks. In the case of slight leaks being discovered under test in compartments which have been caulked in the usual manner, the defects can generally be made good while the water remains in the compartment. In the case of welded work, however, it has been found that the presence of water makes welding practically impossible; so that, to remedy leaks by welding, it is necessary to empty the compartment. In the ship on the raised and sunken system the tests occupied a longer time than usual, and it is therefore proposed that with future welded work the tests preliminary to a final water test should be applied by air pressure. This would probably enable leaks to be detected and made good without delay.

It is expected that as experience is gained the results will be more satisfactory, but it is not anticipated that it will be practicable to apply welding to all parts of a ship's structure on account of the unreliability of overhead welding, and it does not seem likely that welding will entirely supersede riveting for non-watertight work—at any rate, not for some appreciable time.

The clinker system was shown to be decidedly superior to the raised and sunken system, and the advisability of welding up work at the early stages when it was more accessible was clearly demonstrated.


Continuous Weld for Length of Liner
Continuous Weld Round Bulk^D
Liner
Bulkhead
Continuous Weld for Length of Liner
Tapered Liner
Continuous Weld
90lb Raised Strake of Shell Plating
Boundary Angle
Continuous Weld
Continuous Weld for Length of Liner

SKETCH 11.—RAISED AND SUNKEN SYSTEM AND CONTINUOUS WELDS. A-A SECTION SHOWING METHOD OF WELDING BK^D IN WAKE OF LINERS.

CONCLUSION

Summing up: American and British practice differ in the following interesting points:

Americans favor spot welding for bracket and suchlike connections, while the British prefer riveting.

For right-angle watertight connections the American practice tends to heavy welding, the British to riveted angles, the rivets being widely spaced and backed up by lighter welding, or to notch angles with light intermittent welding.

For butts, notched or riveted straps with widely spaced rivets and one run of heavy welding at the joint are preferred by the British instead of a strap lightly arc-welded to the plates with heavy welding at the joint, which appears the present tendency in America.

For plate edge joints, British practice favors a riveted lap with widely spaced rivets, while the American practice is to dispense with riveting entirely.

Finally, experience in Great Britain shows that at present arc welding should not be applied to mild steel plates of greater thickness than 25 pounds, nor can it yet be used on galvanized or high tensile steel; but the writer has heard of no such limits being imposed in this country.

Sixth Discussion.

ELECTRIC WELDING PRACTICE AT THE SUBMARINE BOAT COMPANY'S PLANT*

By CLARK HENDERSON,
Plant Manager, Submarine Boat Company.

WITH no conception of the later uses which have been found for electric welding in connection with ship construction at the Submarine Boat Company's yard, some of us who, prior to coming to the company, had had more or less experience with electric welding, thought that in some places, at least, welding could be used, and with no more definite purpose in view, ordered an electric welding outfit. That equipment had not been very long in the plant, however, before it was found that it was busy all of the time. From that time new applications have come up almost continuously, until at the present time about six hundred operations are performed by electric welding; and, in the writer's opinion, this extension of electric welding to ship construction will continue until the completely welded ship is realized.

FIELD WORK VS. DESIGN

In electric welding, as well as in any other experience of the writer's in the development of new methods, the pioneer work was done in the field. At the beginning an absolute antagonism was felt by our designers against electric welding in any of its phases in connection with ship construction, with the result that a start was made only as the desires and the necessities of the shop for a quicker and cheaper process compelled the field men of themselves to search for better methods. It was in this way that electric welding was started in the Submarine Boat Company's plant.

VIEW OF ONE OF THE SUBMARINE BOAT COMPANY'S WELDING SHOPS

ELECTRICALLY WELDED FRAMES

Good suggestions are, however, now coming from the designers and others who, at the start, were most strongly prejudiced against the work, and who are being won over in spite of themselves, although, as yet, it has not been possible to persuade the draughting-room to plan electric welding operations in advance of field performances. Nevertheless, it is confidently expected that within the next eight months or a year those who have no interest in ship construction other than design will, due to the results accomplished in the field, substitute electric welding for much of the work in which they now call for riveting.

WELDING TRAINING SCHOOL

The difficulty of securing a sufficient number of good operators became early apparent. Fortunately, however, the Submarine Boat Company sent one of their most capable and intelligent welders to the Emergency Fleet Corporation's training school for instructors at Newport News, and he came back a competent instructor. From this beginning the company has been able to organize their own training school, which has worked out so successfully that, due to the time and money lost in otherwise determining the competency of new applicants, it is now being considered whether it would not be advisable to require all applicants hired at the gate to pass through this training school, so that the acceptance or refusal of their services could be determined there in advance of any trial in the field.

D. C. VS. A. C. EQUIPMENT

At the beginning of our electric welding work, we had at our plant, naturally, the same ideas prevailing elsewhere, viz., that welding should be done with direct-current equipment under conditions of approximately constant current and a fairly low voltage. After experimenting with one type of apparatus after another, and after obtaining data from other places, we felt that we had more or less exhausted the possibilities of the direct-current field, and that good welding was, after all, up to the operator.

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* Delivered in the auditorium of the Engineers' Club of Philadelphia, Wednesday, August 31, 1918.

ELECTRICALLY WELDED UPPER DECK HATCH COAMING

About this time the writer became interested in the alternating-current welding equipment, and finally came to the conclusion that there was little or no doubt but that the arc was more difficult to maintain with an alternating welder than with a direct-current machine. With this in mind, the thought came that, because of the difficulty in maintaining the arc, it would be a good idea to use alternating equipment in our welding school, the theory being that an operator who had become efficient in maintaining an alternating arc would find work with D. C. equipment comparatively easy.

In using A. C. equipment in the training school, while it was found that it was almost impossible to maintain a long arc with this apparatus, and, as a consequence, A. C. welding seemed slower than D. C. welding, it was also found that, due to the shortness of the arc that could be maintained, the molten metal from the electrode always seemed to drop on that part of the surface which was at welding temperature. Therefore, a good weld was obtained, or none at all.

In addition to this feature, as compared to D. C. equipment, alternating-current machines have the advantage of less first cost, and, consequently, less stand-by loss; they are lighter, and hence more easily moved to any part of the ship; they have no moving parts, and therefore are not only more cheaply maintained, but can be used from positions in which it would not be possible to place rotating apparatus.

On the other hand, we have found that alternating-current machines are harder to use on overhead welding; somewhat slower than D. C. equipment; and that considerable precautions must be taken to avoid a low-power factor and the unbalancing of the system.

BASIS OF WELDER'S COMPENSATION

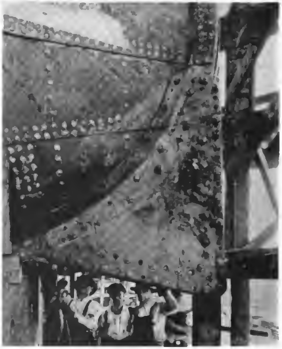
Piece work has been adopted in our plant, in addition to the hourly rate fixed by the Government, for the reasons that we are not only willing to pay better wages to the more skilful and energetic operators, but because we find that it is necessary under this system to lay out the work more carefully, so that the workmen shall be caused no delay due to lack of prompt and efficient supervision.

In piece work the prices paid are based on pounds of metal deposited plus an allowance for time lost in setting up the job and getting it out of the way, so that a proper balance might be struck between the man on piece work requiring heavy welding and the operator on a job requiring only light welding and a corresponding greater loss of time in changing from one job to another.

Bearing these points in mind, the following rules have been used with considerable success:

1. All work must be set up and laid out for the welders.
2. Welders must use wire up to within 1½ inches of the electrode.
3. Work must pass the Government inspection, all defective work being charged to the operator.
4. In case of special jobs, the same shall be paid for at the existing rates.
5. In case of shortage of piece work, day rates now in effect will apply.
6. Operators will be given class of work which is in accordance with production requirements.

Working under these conditions, and, further, with



OTTER GEAR IN POSITION FOR WELDING TO STEM the men understanding that the best operators would be given an opportunity to select piece work, we have found that not only is the work speeded up, but that the men have done satisfactory welding and at the same time earned about 25 per cent. more wages.

INSPECTION AND TESTING

The acceptance or rejection of both time and piece work is based primarily on the inspection of the Government. In piece work, however, no payment is made until our own inspectors and supervisors, either through superficial examinations, such as those that can be made with a hammer, or by hydraulic or tensile tests are satisfied with the work.

In the shops, where one man's entire time is devoted to inspection, in addition to such assistance as the foremen can give, we have no great difficulty in exercising close supervision, although in the case of welding on the ship, one man, having in charge four or five welders, may find that, at times, his men are spread out over a radius of an eighth of a mile, and that, therefore, the same attention to the work of each cannot be maintained. Up to the present time, however, we have used welding on eleven ships, with the result that, although most of this work was for water- or oil-tightness, we have had to reweld on very few occasions.

PLANT LAYOUT

Present plans for the Submarine Boat Company's plant contemplate one electric welding outfit per way, one for each of the shops at the dock, and about twenty for the welding school. The writer is, however, firmly convinced that before completion each way will have four welding outfits. Up to the present we have been using D. C. equipment in the shops, but now that such encouraging results have been obtained with alternating current it is planned to give the shops both systems.

When completed, the plant will have ten 635 H.P. and two 350 H.P. motors, in addition to the several rotaries, so that it is felt that the question of power factory will not come up. With so many welding outfits in use, we believe that it will be possible to arrange for a distribution of operators over the various circuits in such a way as to avoid any serious unbalancing in the alternating current system.

VIEW SHOWING LOCATION OF WELD IN HATCH COAMING

VIEW OF TANK SHOWING 9" HOLES PLUGGED UP BY ELECTRIC WELDING

ELECTRIC WELDING APPLICATIONS

As previously mentioned, about six hundred operations are performed by electric welding on each hull built by the Submarine Boat Company. Some of the typical work is shown in the accompanying photographs.

A few of the many other applications which may be of interest are:

The splicing of electric welding of sheet piling used in the construction of cofferdams in the erection of the plant where deeper water was encountered than was estimated; the welding of plates cracked in the vicinity of the punching during the process of fabrication; the welding of leaky rivet heads; the corners of hatch coamings, and a great variety in both repair and new work of welding for water- or oil-tightness.

CONCLUSION

So far as our present experience has gone, it appears to us that, all things considered, the alternating-current practice is better than the direct current, with the possible exception of overhead welding; that with bare electrodes it is perfectly possible to do satisfactory work, and at a lesser cost than with covered electrodes; and that the very material saving already found in both time and expense in the present limited application of electric welding to ship construction will continue to be found until riveted fabrication is entirely supplanted.

On the other hand, with an art that is developing so rapidly, we realize that no final conclusion can now be reached, and we are, therefore, prepared to take up new ideas or new phases of old ideas as they may appear.

(The concluding discussions will be published in the December issue of the Journal.)

THE MANUFACTURE OF ORDNANCE FORGINGS*

By GEORGE SATTERTHWAITE, Member

A general description of the various methods and devices used in the manufacture of ordnance forgings.

BY referring to the Century Dictionary, published in 1917 by the Encyclopædia Britannica Press, we find the following definitions of the words "Ordnance" and "Forging":

Ordnance (*Noun*). The general name for all kinds of weapons in warfare; cannon of all kinds including mortars, howitzers, artillery. As a technical term it designates all heavy pieces fired from carriages.

Forging (*Noun*). A piece of worked metal, as in iron or steel; and

To Forge (*Verb*). The act of heating or working iron or steel.

From the above we see that the word "Ordnance" is a generic term, and while technically it may be correctly applied only to certain definite things like heavy guns, it has come in the popular mind to include practically everything with which a soldier or an army or a navy makes war upon his enemy. For the purpose of this paper, however, "Ordnance" will be arbitrarily divided into the following classes: Cannon, Shells, Armor and Miscellaneous.

Under "Cannon" will be included rifles, both small and large, howitzers, mortars, trench mortars, *et cetera.*

Under "Shells," armor and deck piercing projectiles, high explosive shells, shrapnel, gas shells and, in general, everything that is propelled by any of the various weapons included under cannon for the purpose of doing damage to an enemy.

Under "Armor" will be included everything from the thin steel shield or helmet to the heaviest port plate armor of the battleship.

And under "Miscellaneous" all other articles and parts of articles used by the army or navy for the purpose of inflicting damage upon the enemy.

By referring again to the dictionary we note that the name "Forging" means "a piece of worked metal," and in this paper "Ordnance forging" will mean the semi-finished article out of which, by further machine work and assembly with other articles or parts of articles, is made the finished piece of ordnance, whether a Navy rifle or a round of shrapnel.

MECHANICS AND METALLURGY

The manufacture of ordnance forgings made of steel involves the following steps: Making the ingot of suitable size, shape, composition, *et cetera;* forging the ingot to the shape desired; heat treating, including annealing, quenching and drawing and testing; and machining. The metallurgical principles involved are simple in themselves and are well known to any metallurgist familiar with the manufacture of steel; but the application of these simple principles to the large masses of metal required in most ordnance work, and the elaborate and ponderous mechanical devices necessary in carrying out the metallurgical prescription, call for skill and experience.

In these steps two distinct sciences or professions are involved—mechanics and metallurgy—and it is the necessarily close co-ordination between these sciences that renders the manufacture of ordnance forgings not only interesting, but also difficult and hazardous. For instance, the heat treatment of a gun forging consists usually of three steps:

First, an anneal after forging, usually at a temperature above the critical temperature, for the purpose of relieving forging strains, securing the desired degree of grain refinement and softening for machinery.

Second, a quench in some medium from above the critical temperature; and—

Third, a draw to relieve the quenching strains, and to give the desired physical properties.

These are the same steps that are applied in the heat treatment of an automobile axle weighing 50 pounds, but their application to a large gun tube, 65 feet long, weighing 75,000 pounds, calls for extreme engineering skill.

The art metal worker who shapes by hand on his anvil a beautiful piece of ornamental iron work need not know much about the metallurgy of iron, but he must be a very skilful mechanic; the making of millions of wire nails or tacks a day is not a serious metallurgical problem but is a beautiful example of mechanical ingenuity; the making of a good car axle involves more metallurgical consideration than the two former examples, but still does not call for any great skill or knowledge in this science. The making of thousands of shrapnel or high explosive shell bodies per day on one machine is primarily a mechanical problem, though much consideration must be given to metallurgy, whereas the making of armor-piercing projectiles, armor plate, gun forgings and parts of airplane motors and automobile torpedoes requires first of all a thorough understanding of the metallurgical principles involved and the skill and experience necessary to combine those principles with the ofttimes difficult mechanical problems.

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*Presented before the Philadelphia Section, American Society of Mechanical Engineers, May 28, 1918, at the Engineers' Club.

Before considering the manufacture of particular items of ordnance, it may be well to describe briefly the equipment required to carry out the various steps of manufacture, which equipment is common to all articles of ordnance, differing principally in size and other details.

MAKING THE INGOT

Originally the crucible was used almost entirely for making all high-grade steels, but in recent years the development of the open-hearth furnace has made it a close rival in quality with the crucible. As a crucible pot rarely holds more than 100 pounds of metal, it can be seen how difficult it would be to make an ingot weighing 100,000 pounds by this method, though up to a few years ago a prominent foreign ordnance maker did make large ingots from the crucible, this being possible only by using a very great number of men carefully trained and drilled—a beautiful example of team work.

Very recently the electric furnace has been used for making ingots for ordnance forgings, but as the electric furnace is usually of but six tons capacity, only ingots for the smaller forgings can be cast. The open-hearth remains, therefore, the principal means of making ordnance steel—the most popular size being of 50 tons capacity.

Any type of fuel suitable for heating open-hearth furnaces is satisfactory for ordnance work, though producer gas and crude oil are used most extensively. Consideration must be given, however, to the design of the furnace for ordnance, particularly to the shape and dimensions of the hearth—it being necessary to secure a satisfactory relation among the length, width and depth of the bath. In general, however, any well-designed furnace can be used to make good ordnance ingots. As the acid bottom is more generally used than the basic, great care must be exercised in selecting the proper raw materials, not only to meet the chemical specifications, but to insure the necessary purity of the steel. Assuming, then, an ordinary well-designed furnace, the secret of making good ordnance ingots lies, first, in the proper handling of the metal in the furnace and, second, in the method of pouring. Opinions vary among experts, but in the writer's belief, the making of the ingot is by far the most important step in the manufacture of ordnance forgings.

The two great American ordnance makers, both located in Eastern Pennsylvania, differ widely in the details of open-hearth practice for ordnance, and if you want to "start something," get the experts from both plants discussing this subject. Having been trained in the Forge Department of one of these plants, and having always been impressed with the tremendous importance of forge work, I must admit that good ordnance is made in the open-hearth department, the succeeding steps being of relatively small importance.

A few of the many much-discussed important points in making good ordnance ingots are: Method of solidifying or killing the heat, the addition of finals, the temperature of the bath, the kind of slag, the time of holding in the ladle, top or bottom pouring, chilled or sand mold, big or little end up, hot tops, rate and temperature of pouring, etc., etc.; but the most minute and careful attention must be given to each of these points, and their relation one to the other, if good ingots are to be made. Even after a satisfactory procedure is laid down and established, it requires eternal vigilance all along the line to keep up the established practice. "Quality" must be the watchword and not "tonnage"—and there must be the strictest discipline in the open-hearth to see that each step is properly carried out by the workmen, very few of whom understand or appreciate the importance of their instructions. A good ingot will make a good gun forging, but all the skill in the world in forging, machining and heat-treating departments cannot make a good gun forging out of a poor ingot. Up to the present time, the manufacture of ordnance has not been a production problem—rather a specialty; the orders being for ones or twos or dozens of a thing; but in these days, where thousands and millions are required instead of ones and dozens, tremendous pressure must be brought to bear by the management to keep "quality" ever uppermost. It should be borne in mind that in the manufacture of ordnance forgings particularly, the only production that counts is the production that goes out the gate in the form of finished material, and in ordinary times it is poor business, and in these times unpatriotic, if not criminal, to drive the open-hearth department harder or faster than they can make ingots that will go through the succeeding steps of manufacture successfully. Unfortunately, it is impossible to tell whether an ingot, even though apparently just what it should be, will make a good piece of ordnance until after it has passed through all the steps of forging, heat treating and machining—until after all the money and human energy has been spent upon it. It is much better from every standpoint to make only six heats a week per furnace, all of which will go straight through the succeeding steps and go out the gate to France, than to make ten heats per week and have four or even three of them fail of acceptance. Manufacturing schedules should always be so arranged that there will be the minimum amount of "work in process"—that there will be the minimum amount of time between the casting of the ingot and its acceptance after machining and heat treatment. The failures in ordnance forgings that come from faulty heat treatment can always be corrected by retreatment requiring little loss of time or money, but the failures that come from poor ingots (and these constitute by far the larger part) seldom if ever can be cured by the most elaborate heat treatment.

FORGING

There are many kinds of mechanical devices used for forging, but they can all be included in the three classes—presses, hammers and rolling mills. In forging ordnance the hydraulic press is used most extensively, the steam hammer next, and the rolling mill least. For a most interesting discussion on the relative merits of these three machines in working steel I wish to refer you to a paper by John Lyman Cox, Engineer and Metallurgist, Assistant to the General Superintendent of the Midvale Steel Co., read before the American Iron and Steel Institute on May 25, 1917, and published in their Journal.

The steam hammer and the rolling mill are too well known to require any description. The press consists principally of two heads—top and bottom, connected by two or four (usually four) columns or bolts—a cylinder or cylinders, and a ram, actuated by water or other liquid under high pressure, controlling valves, etc. The important advantages of the press for forging are:

1. That they are self-contained and require no enormous foundation to take the blow, as do the hammers; and—

2. There are practically no limitations to their size and power—there being at least one press in existence of 20,000 tons capacity and many of 10,000 tons, the range being from one or two hundred tons up, though for the sizes less than 500 tons many prefer the steam hammer.

There are at least four types of presses, the principal difference being only in the method of securing the necessary pressure of liquid in the cylinder. They are: Whitworth type, the Davy or steam-intensifier type, the hydraulic-intensifier type, and the accumulator type. The Whitworth type uses a high-pressure hydraulic pump driven by steam engine or electric motor connected directly with the press cylinder by means of heavy pipes and controlled by a powerful valve, actuated itself by high-pressure water. For general forging purposes, particularly in the sizes of 5,000 tons or over, this type of press is, in the writer's opinion, unsurpassed, though in recent years the Davy or steam-intensifier type has become very popular, and justly so. This press is operated by a large steam cylinder, the piston rod of which has an extension which moves in a small hydraulic cylinder connected with the main press cylinder by means of pipes and valves. The disadvantages of this type of press are the shortness of the effective power stroke (from 5 to 7 inches) and the heavy steam consumption, though the latter may compare favorably with that of the hydraulic pump used with the Whitworth type of press, which necessarily uses steam or electricity while idling between power strokes.

In the other two types use is made of the accumulator, a vertical cylinder, the piston or plunger of which is weighted down to give the desired pressure, usually not over 2,500 pounds per square inch. By means of valves this water is admitted directly to the press cylinder or through one or more hydraulic intensifiers. These presses are admirable for certain classes of work, but are generally slow-acting or of very short effective stroke.

As many of the pieces of guns or armor require ingots of great weight, 100,000 pounds to 200,000 pounds each being quite common, and armor ingots running frequently to 300,000 pounds each, it is necessary to provide, in addition to the forging press itself, very powerful and elaborate handling and manipulating devices. These usually consist of overhead travelling cranes (all motions of which are electrically operated except the hoist, which is preferably hydraulic), chucks, mandrels, porter bars, sling chains, cutters, etc., besides the usual electric travelling cranes. For lighter work the electric manipulator, when properly designed and constructed, is most satisfactory, particularly if it is hung from an overhead runway. It usually has seven motions, all operated by electric motors: Travel in both directions, rotate, elevate, raise or lower boom, rotate boom, open and close jaws; and in the hands of a skilled operator is wonderfully efficient. For still smaller work, particularly at steam hammers, the weight is carried by a small jib crane only—everything else being done by the hammer gang, with tongs and bat stick, levers, etc.

While forging does not necessarily imply that the metal is heated, it is of course assumed that all work referred to in this paper is done under proper conditions of heat. It is here that the metallurgical phase of the forging problem enters, and as alloy steel is used very extensively in ordnance work—nickel and nickel-chrome being the most used—and as many of the ingots are of great size, the heating of the metal becomes a very important part of the work.

There are furnaces of various kinds and shapes, of which the roll-down or long-tail, the car-bottom and the hearth types are most common. They are fired with any kind of fuel, dependent upon local conditions, relative cost, etc.; coal hand-fired, coal stoker-fired, oil, producer gas, natural gas and powdered coal all being satisfactory from a metallurgical standpoint. Oil, owing to the cheapness and simplicity of the equipment necessary, and its great flexibility, is very popular, but by no means the cheapest. Powdered or pulverized coal is coming into extensive use, and when the entire equipment, pulverizers, dryers, conveyors and burners, have been properly designed and installed, it is a very satisfactory and economical fuel. For those so fortunately situated as to have natural gas, this must of course be a very cheap fuel.

In general, steel for ordnance should be brought slowly to the proper heat, not over 2,200 degrees Fahrenheit, and preferably about 2,100 degrees Fahrenheit, after which it should be allowed to soak until it is certain that the entire body of the ingot from center to outside, from top to bottom, is at a uniform mellow heat. The ordinary soaking pit practice commonly used in the manufacture of rails, structural steel, commercial bars, etc., is not good enough for ordnance.

Usually, in handling the larger ingots used for making parts of big guns and armor plate, the manufacturing schedule is so arranged that the piece is never allowed to get entirely cold from the time the metal is poured into the mold until the finished forging is annealed. In other words, the ingots are taken hot, but not too hot, from the open-hearth, and charged immediately into the heating furnace at the press; though preferably, from a production standpoint, they are sometimes charged into a preheating furnace before being placed in the heating furnace. The length of time an ingot can be worked without reheating is a question of mechanics and production rather than metallurgy. It is unwise to allow a nickel or nickel-chrome ingot of larger section than 40-inch diameter to grow cold without annealing.

Ordnance forgings are of varied size and shape, some being plain round cylinders and others being square, rectangular or with lugs. Armor plates for battleships, being almost always plain rectangular plates, are comparatively easy to forge, except for the difficulties involved in their great size and weight. Shells and projectiles are forged hollow (squirted or extruded) or solid, depending on the circumstances. Gun tubes and hoops are forged both solid and hollow, the determining feature being relative speed and cost as well as metallurgical reasons. Inasmuch, however, as gun forgings are almost always tested transversely to their axis, it is well to do some transverse working wherever possible, either by upsetting or by expanding on a mandrel. The design of dies, mandrels, etc., is very important in ordnance forging, but no more so than in ordinary forging.

ANNEALING

After forging, the next operation is annealing. As mentioned before, this operation is for the purpose of relieving forging strains (which unrelieved may cause the piece to crack), grain refining, and softening, for machine work. The particular formula or prescription to be used in annealing will depend upon several conditions, the size and thickness of section, the temperature at which it left the forging tool, the composition, etc. The usual treatment consists in heating the piece to a temperature above the critical temperature, holding it at this temperature for a sufficient time to insure uniformity from end to end and from center to outside, and for the reaction to take place, and then cooling, either quickly or slowly, depending on circumstances. Sometimes a crude quench is combined with the annealing, by heating farther above the critical temperature and cooling in air to a temperature below the critical, followed by another heat to a lower temperature but above the critical, followed by a slow cool. To secure extreme softness for machining, this may be followed by an anneal (or draw) from a temperature just below the critical.

These annealing operations on gun forgings are usually done in an ordinary box furnace, having lids or covers for charging and discharging—this type being sometimes called a "bung-top" furnace. Any fuel will do, but crude oil is usually employed, with suitable burners at intervals along both sides. It is, of course, very important that the forgings are heated uniformly, and to determine this pyrometers are inserted at suitable places, the number depending upon the length of the piece and the accuracy desired.

Great care must be exercised in setting forgings in the furnace, particularly long, thin ones like gun tubes, in order that they do not become warped, as they are usually straight when forged, or should be.

ROUGH MACHINING

The next step in manufacture is the rough machining. Depending upon the size and shape of the pieces, they may be machined to the final rough-machined size before the quenching and drawing treatment or given a preliminary machining, the final rough turning and boring being done after acceptance for physical properties. In either case the operations are almost identical. The tools used in rough machining gun forgings are turning lathes, boring lathes, planers, shapers, slotters and occasionally milling machines and horizontal boring mills. In machining the medium and larger sizes of gun forgings, heavy duty machines designed and built for the purpose must be employed if large production is to be secured.

In machining a gun forging, a tube for instance, the operations are as follows:

1. Preliminary turn, to develop surface seams or other defects and to secure steady rest bearings.
2. Bore, sometimes from one end and sometimes from both; and
3. Final turn on plug centers set in the bore, to insure concentricity of outside with bore. In the case of jackets and hoops having lugs, planers and shapers or slotters are necessary in addition to turning and boring lathes. In determining how much machine work is to be done before quenching and drawing and how much after, due consideration must be given to the following:

In general the surface skin of the forging should be removed, together with all surface defects contained therein; otherwise, a crack may start in the subsequent heat treatment. Sufficient machining should be done to reduce the section as far as practicable, but the minimum amount of work should be put on the piece before it is accepted, otherwise this expense may be entirely wasted, due to the failure of the tests.

In boring from the solid very long pieces, such as gun tubes, double-ended boring machines are used very successfully, though care must be used to have the holes match properly. The larger of these machines sometimes have hydraulic feed to the boring bars with screw release, thus throwing the heavy load off the lead screws. The designs of cutter heads and cutters vary in different shops, each, of course, claiming superiority for their own equipment. All, however, agree that large quantities of boring compound or lubricant at high pressure should be used, not only to keep the cutting edges cool but to wash away the chips, which if allowed to remain cause jamming and breaking of cutters and cutter heads. The rough machining of ordnance forgings is the easiest of the four steps and requires no metallurgical skill or knowledge, but does require considerable mechanical skill and experience.

HEAT TREATMENT

The fourth step in the manufacture of ordnance forgings is the "heat treatment," which consists primarily of quenching in some cooling medium from a temperature above the critical, followed by a draw at the proper temperature to give the desired physical properties. In the case of gun forgings, which, of course, are hollow, good practice calls for the heating for quenching in a vertical position and dipping in oil or other liquid in the same position. Like the annealing furnace, these vertical quenching furnaces are usually fired with crude oil, the burners being so arranged as to give uniform heat without direct contact between the flame and the forgings.

In size these vertical furnaces vary from 6 feet to 12 feet inside diameter and from 10 feet to 100 feet inside length. The charge is usually suspended on dogs which are hung from the furnace binding. The furnace is charged and discharged through the open upper end, which is covered during heat with a lid or cover capable of being removed quickly; this may be done by any suitable mechanical means. In the longer furnaces, say, over 25 feet, it is sometimes considered desirable to have a long, side-opening door the entire length of the furnace, the door section in a circular furnace being about one-third of the circumference. The advantage of this type of door is the saving in time in getting the piece into the quenching bath—a consideration of great importance; also a saving in head room.

As stated before, the heat treatment of a gun forging depends upon the same simple metallurgical principles as the heat treating of an automobile axle, the difficulties arising only from the usually great size and weight of the pieces. Here is where engineering skill and experience are required, to devise the proper arrangement of cranes, hoists, furnaces, tanks, etc., so that the piece when ready may be removed from the furnace and immersed in the quenching medium in the shortest possible period, and may be removed from the bath promptly and quickly when the proper time has elapsed. As the immersion occupies only a few minutes, the forging is held by the crane during this time.

Various quenching mediums are employed, depending upon conditions, from oil to chilled water, the former being the most common, though for the symmetrical pieces water may be used if great care is exercised to prevent cracking. Water is more drastic and more effective, but also more dangerous, and its use cannot be recommended indiscriminately.

The drawing operation after the quench may be done in a vertical position, though more often it is performed in a horizontal position; in the former the same kind of furnace may be used for drawing as for heating for quenching. The advantage of the vertical draw is that the piece is less likely to warp or bend when suspended vertically than when supported on blocks horizontally. In horizontal drawing, the "bung-top" box furnace may be used, but the best practice is to use a car-bottom with an overfired or underfired combustion chamber, the charge being virtually in a muffle, where accurate control of temperature may be maintained.

The advantage of the car-bottom type lies principally in the ease with which the charge may be properly set. As the drawing temperature is of course below the critical temperature, theoretically the piece can be cooled quickly from the drawing temperature; but in ordnance work this practice should be avoided because of strains that may be set up, which may show up in warping when the piece is being finished-machined for assembly.

Both the quenching and drawing furnaces should be accurately controlled by the best pyrometer equipment obtainable, to determine whether the prescription has been correctly followed and to record the actual conditions during the heat.

TESTING

The specifications provide that tests for physical properties shall be made to determine whether the piece has the proper strength, ductility and toughness to meet the requirements of the designer. In gun forgings, as the greatest strains are those tending to burst or split the gun, the transverse or tangential bar is taken to determine the strength of the tube or hoop in this direction. These tests are taken from suitable prolongations provided at one or both ends, turned or ground to the proper size, American practice being 0.505" dia. x 2" between measuring points, and then broken in a tensile testing machine, and the tensile strength, elastic limit, percentage of elongation and percentage of reduction of area at point of fracture determined. The most common specifications in physical properties call for a tensile strength of 95,000 lbs. per sq. in.; an elastic limit of 65,000 lbs. per sq. in.; 18 per cent. stretch and 30 per cent. contraction of area; these being the requirements for nickel-steel gun forgings for both our Army and Navy.

When the test bars are broken it is known for the first time whether the ingot was properly made and whether the forging and the heat treatment were properly done. If the piece meets the test in all the bars required it is provisionally accepted, after which it is cut to length and sent to the machine shop for further machine work.

SPECIFICATIONS

The chemical requirements in American gun forgings are: Phosphorus and sulphur less than 0.05 per cent.; these being the principal deleterious ingredients in steel. Foreign specifications sometimes place limits on other elements, particularly copper, though copper in reasonable quantities, say, up to 0.25 per cent. has not been considered harmful in this country.

The subject of specifications for ordnance forgings is a large one and can only be touched upon lightly in this paper. The chemical and physical requirements mentioned above constitute the meat or heart of the American specifications, but there is one other important requirement, namely, the amount of reduction from the ingot to the forging. The specifications for gun forgings call for a reduction of area of 4 to 1 from the ingot to the forging; for instance, a 20 in. diameter forging requires a 40 in. diameter ingot or its equivalent. This provision is subject to much just criticism for this reason: By the physical law that causes steel to expand when heated and to contract while cooling, and, further, because steel is a mixture of elements which in combination with iron have different melting or solidifying points, the larger the ingot the more difficult it is to secure a good ingot.

The decrease in quality of the ingot with respect to segregation, etc., is believed to be in the ratio of the square of its diameter, and whether this is correct or not, it is an indisputable fact that the difficulties increase greatly with the cross-section of the ingot; therefore, as small an ingot should be used as will insure a thorough working of the metal in the forging; certainly a reduction of area of 2 to 1 from the ingot to the forging should be sufficient. An ingot is a casting, and a forging is better structurally than a casting; therefore, the ingot should be worked thoroughly to break up the bad ingot structure; but it is very unwise to use an ingot of larger section than is absolutely necessary.

The foregoing very general description of the operations of ordnance manufacture applies particularly to the manufacture of gun forgings, a name given to the articles which, when finished, machined and assembled, constitute a gun or cannon, referring particularly to sizes above 3 in., whether howitzers, rifles or mortars. In the manufacture of the other items of ordnance—armor, shoulder arms, machine guns, shells, gun carriages, etc., etc.—some or all of these manufacturing steps are taken, though differing greatly in detail.

ARMOR

The purpose of armor is to protect whatever is behind it, but particularly to prevent the bullet or shell or projectile from passing through it and thereby damaging men or machinery. The thin armor used for helmets, breast plates and gun shields, usually less than ½ in. thick, is intended to be proof against penetration of the rifle or machine-gun bullets, which are generally about 0.30 in. in diameter and have muzzle velocities of from 2,500 to 3,200 ft. per sec. The modern rifle bullet is steel-jacketed and has tremendous penetrating powers, particularly at ranges up to 300 to 500 yds. The problem, therefore, of making a plate light enough for a man or a motor car to carry and still strong enough to withstand the bullet is an interesting and difficult one. For this purpose a very high-grade steel is used, quite often of crucible or electric-furnace manufacture, alloyed with nickel, chromium, molybdenum, tungsten, zirconium or combinations of them. The steel must have extreme strength or hardness, and yet sufficient toughness and ductility to prevent fracture or shattering. This armor, being so thin, is a product of the rolling mill. After rolling it is annealed, then machined and bent to size and shape, then heat-treated and tested ballistically, and after acceptance straightened or rectified cold. In this condition it is still usually soft enough to drill and tap or even bend, but will not flange or take sharp bends very readily.

Armor for ships or fortresses, while intended to serve the same purpose as the thin shield—viz., to prevent penetration of shell or projectile—is a very different manufacturing problem. For ships the thickness will vary from 4 in. to 16 in. or 18 in., but at the present time the greater part of the armor protecting battleships is about 13 in. thick; in width up to 10 ft., and in length up to 30 ft.; single plates weighing as much as 125,000 lbs.

To prevent penetration by the armor-piercing projectile it is necessary that the face be very hard and strong, perfectly supported by a softer and very tough back. Nickel and chromium in proper percentages are used, the rest of the composition being plain carbon steel with carbon 0.20 to 0.50, depending on other conditions. In order to get the necessary hardness in the face it is customary to carbonize or cementize, each maker having his own carefully worked-out and carefully guarded formula for this delicate and important operation.

The ingots are usually cast rectangular, with thickness to give sufficient forging reduction and length and width to give the required weight and to suit the mechanical devices used in forging. They are cast in sand or iron molds and have, of course, sufficient risers, sinkheads or tongholds to insure necessary solidity and freedom from piping. As they are made of nickel-chrome steel and weigh 200,000 to 300,000 lbs. each, they must be taken hot from the open-hearth and charged in heating furnaces, which, except for their great size, are no different from other ingot-heating furnaces described before. For forging, a powerful hydraulic forging press is used, of about 10,000 to 15,000 tons capacity. After forging, the various heat-treating, bending and machining operations are carried out.

For purposes of test, armor is manufactured in groups of about 400 to 600 tons each, and after all the plates in a group have passed through all of the heat-treating steps and are found to be uniform as far as can be determined by means of scleroscope, Brinell, tensile test, micro and macrostructure examinations, one of the plates is selected for ballistic test, which if successful accepts the group. After this the remaining plates are machined to final size and sent to the shipyard. The tool equipment for making armor is massive and powerful, but must be capable of very delicate control, and, for handling, very ingenious auxiliary equipment must be employed.

SHELLS AND PROJECTILES

The high-explosive shell is usually nothing more than a container or carrier for the high explosive itself, the gun and shell being used to place the high explosive where it is thought it will do the most good; it has no penetrating to do other than through light breastworks, walls of buildings, etc. For greatest efficiency, therefore, the high-explosive shell has as large a cavity or containing capacity as is possible, with the necessary strength of wall to stand the shock of being fired from a gun at high speed.

Another important function of the high-explosive shell is the damage done by the fragmentation of the shell body itself, and the shell is so designed with respect to thickness of wall and physical properties as to give the desired fragmentation.

The armor-piercing shell, on the other hand, while its mission is to cause a damaging explosion where it is desired, has the very difficult job of getting through a piece of armor designed and constructed to keep it out, and, further, the armor-piercing projectile must not explode its charge until after it gets through this supposedly impenetrable armor plate. We have here a beautiful example of an irresistible force meeting an immovable object: the projectile to be successful must go through the plate, and the plate to be successful must keep the projectile out. This apparently hopeless situation is a great bone of contention between armor and projectile makers, and is particularly embarrassing where one company makes both armor and projectiles. As the armor plate has a hard face supported by a tough back, so the armor-piercing projectile has a hard point and a tough back. The hard face of the armor is intended to smash up the hard point of the projectile, and the hard point of the projectile is intended to smash the hard face of the armor, and here we have a merry war.

Armor-piercing projectiles are made by crucible, electric-furnace or open-hearth, of high-carbon alloy steel, forged under a press or steam hammer much as an axle is forged. The machine work is simple, requiring principally medium-size but powerful high-duty turning and boring lathes and grinders for the bourrelet. The heat-treating operations are, however, very elaborate and complicated combinations of annealing, quenching and drawing. In the writer's opinion the manufacture of large armor-piercing shells to meet the present American specifications is the most difficult problem in the metallurgy of steel today, and only in very recent years have one or two concerns been able to take it out of the laboratory and place it on a manufacturing basis.

On the other hand, the high-explosive shell or shrapnel body is a comparatively simple metallurgical problem, and not an extremely difficult mechanical problem. For this purpose a simple carbon steel is generally used, though the physical specifications sometimes make it necessary that some heat treatment be done. The usual steps are as follows: Casting the ingot, any standard size and shape, say, 30 in. square; blooming and rolling to the desired round; slicing into units or slugs of the proper weight; forging by punching or squirting, or by punching and drawing on a bench; annealing (or quenching and drawing); and finally machining and assembling with base plug, fuse, rotating band and other parts.

SOLUBILITY AND FUSION RELATIONS AT HIGH TEMPERATURES AND PRESSURES*

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The great mass of chemical experience is concerned with a small portion of the great field which represents the conditions of temperature and pressure under which chemical reactions can take place. Most investigations have been made at ordinary temperature and pressure, though much work has been done at high temperature with non-volatile oxides such as lime, silica, and alumina, and at ordinary temperature and high pressure. The geochemist in studying the processes of rock formation and mineral genesis, is concerned with the simultaneous action of both high temperature, up to the points of pure oxides such as silica or lime, and high pressures, pressures such as that produced by the weight of rock masses from a few hundred feet to miles in depth. Moreover, the simultaneous action of these extreme conditions must be studied not only with systems composed of non-volatile components such as lime and silica, but also with systems containing both non-volatile components and volatile components, such as water or carbon dioxide. In this paper some of the basic principles underlying such systems are discussed and exemplified, and experimental methods which have been used in their study are discussed.

THE phenomenon of solubility is one of the everyday experiences of the chemist, and most of his daily operations are performed on or with solutions. We are all familiar with the ordinary facts of solubility, and in the chemical hand-books is amassed a great deal of information in regard to the solubility of various substances in different solvents. Most of our experience, however, relates to ordinary temperatures. A great mass of solubility data is available for such temperatures, but the solubility of few substances has been determined up to the boiling point of the saturated solutions, and almost no quantitative information is to be had concerning the further portion of the solubility curves.

WHAT IS MEANT BY SOLUBILITY

The term "solubility" is one so often used in a loose sense that its precise meaning is frequently lost sight of. Indeed, its original meaning was a loose one, merely indicating that some substance, usually a solid, disappeared, wholly or in part, the material passing into coexistent liquid phase.† In this sense we often speak of the relative solubility of metals in acid, our conception usually being merely one of relative rate of solution.

When we introduce quantitative conceptions of solubility we have to include certain restrictions to make our meaning precise. When we speak of the solubility of a gas in a liquid, it is necessary to specify the temperature and the pressure of the gas. When we speak of the solubility of a solid substance in a solvent, it is necessary to define the temperature, when we are dealing with a strictly two-component system. We usually are dealing with solutions of non-volatile salts in water, and the system may be regarded as a "condensed" system; the vapor pressure of the solution is less than the prevailing atmospheric pressure and need not be considered. In the general case of equilibrium between solid, liquid and vapor phases in a system of two components, fixing the temperature renders the system invariant; the vapor pressure of the saturated solution is fixed, and may be expressed as a function of the temperature.

When we are considering systems of more than two components further restrictions are necessary. If the liquid phase is a mixture of water and alcohol, to make the solubility of a salt at constant temperature have a definite meaning it is necessary to specify the ratio water to alcohol in the liquid phase; it is necessary to fix the composition of the solvent. The system has one more degree of freedom.‡

We will confine ourselves to binary systems for the remainder of our discussion. Even here we find the problem presents many complications—far too many to more than touch the high spots. To begin with, we will exclude the many cases in which unmixing occurs, *i.e.*, in which two liquid layers are formed. We will also exclude from consideration at present the cases in which the solubility of the solid phase decreases with the temperature, and at first assume that the solute is non-volatile. The subject may then be considered under two heads. First consider only the case that the solubility is considerable, great enough so that no saturated solution shows the critical phenomena; then consider the case that critical phenomena are met with.

THE PROCESSES OF SOLUTION AND FUSION ARE IDENTICAL!

The first point I wish to show is that the "solubility curve" is a continuous curve, which extends from the melting point of the phase in question to the invariant point, with no break at the boiling point of the saturated solution, and that no outstanding distinction can be made between solvent and solute, or between the processes of solution and fusion. These facts were first clearly perceived by Guthrie§ in 1884; Figure 1 shows the complete solubility curve of KNO_3 in H_2O as determined by him. He worked in closed tubes; weighed portions of H_2O and KNO_3 were sealed up in glass tubes and heated, and the temperature at which the solid phase all disappeared was determined. The dotted horizontal line at about 116° and 36.6 mol per cent. KNO_3 represents the boiling point of the saturated solutions; if a saturated solution be heated in an open vessel it will evaporate to dryness at this temperature; this composition is the most concentrated that can be obtained at atmospheric pressure. But if we are working in closed tubes, so that the water cannot escape, it is plain that the solubility curve is continuous past this point, and up to the anhydrous melting point of KNO_3. The break shown in the figure at 126° is due to a circumstance having no bearing on the subject under discussion, namely, the enantiotropic inversion of KNO_3 from the orthorhombic to the rhombohedral form.

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* Presented before the Philadelphia Section, American Chemical Society, March 21, 1918, at the Engineers' Club.

† This subject is discussed in more detail by Morey and Fenner, J. Am. Chem. Soc., 39, 1226 (1917).

‡ See the further discussion of this point on page 514

§ Guthrie, Phil. Mag., 18, 117 (1884).

Let us compare this solubility curve with some other systems. In Figure 1 we also have the melting point curves of the system $LiNO_3$-KNO_3. In the $LiNO_3$-KNO_3 system, addition of KNO_3 to $LiNO_3$ lowers the melting point of the latter progressively until the eutectic is reached, at which point both components coexist in equilibrium with liquid. Along this branch $LiNO_3$ is the stable solid phase. If we cool a solution richer in $LiNO_3$ than the eutectic it will remain liquid until this curve is reached, when $LiNO_3$ will separate out; the solution is saturated in regard to $LiNO_3$. Similarly, if we heat a mixture of the same composition, the solid will melt completely at the temperature given by the curve; at this point the solid all dissolves in the liquid. We call this the $LiNO_3$ branch of the melting point curve. Similarly, addition of $LiNO_3$ to KNO_3 lowers the melting point of the latter progressively until the eutectic is reached, giving rise to the KNO_3 branch. At a temperature slightly below the melting point of KNO_3 we find that the liquid consists of, say, 999 parts KNO_3 to 1 part $LiNO_3$. If we so desire we may say that 1 part $LiNO_3$ dissolves 999 parts of KNO_3 at this temperature, but we do not usually look at it from that point of view. Also, if we define our terms consistently, we may say that along one branch of the curve $LiNO_3$ is solvent, along the other branch, KNO_3. But such terminology is far-fetched.

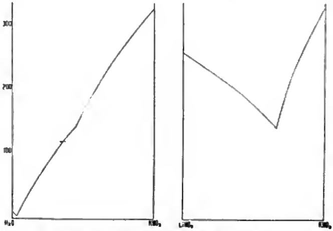

FIG. 1.—SOLUBILITY OR FUSION CURVES IN THE BINARY SYSTEMS H_2O-KNO_3 AND $LiNO_3$-KNO_3.

Compare the H_2O-KNO_3 system with the $LiNO_3$-KNO_3 system. From the point of view of the melting point or solubility diagram they are completely analogous. Along one side of the diagram ice is the solid phase, instead of $LiNO_3$ as in the preceding case; along the other side, KNO_3 is solid phase, just as in the preceding case. Addition of H_2O to KNO_3 lowers the melting point of the latter progressively until the eutectic or cryohydrate is reached, just as $LiNO_3$ does in the preceding case. The curve which proceeds from the cryohydrate point to higher temperatures we are accustomed to speak of as the solubility curve of KNO_3 in H_2O. If we heat a mixture containing, say, about 80 per cent. KNO_3, the last trace of solid disappears when we reach the melting point or solubility curve; the solid melts completely at the temperature given by the curve. If we cool the same mixture from a higher temperature, solid KNO_3 will begin to separate when we reach the solubility or melting point curve; the solution becomes saturated at a temperature given by this curve. At a temperature slightly below the melting point of KNO_3 we may find the liquid phase to consist of 1 part H_2O to 999 parts of KNO_3, just as in the preceding case, and in this case also we may say that 1 part of H_2O dissolves 999 parts of KNO_3, if we so desire. There is evidently no outstanding distinction between solvent and solute, and the processes of solution and fusion are completely analogous. The circumstance that $LiNO_3$ is not volatile, while H_2O is volatile, and requires pressure to hold it on the job is evidently of secondary importance.

As we proceed from the cryohydrate point to regions of higher temperature, the solubility of the KNO_3 increases, as does also the vapor pressure of the saturated solution. When the temperature has been raised to 116°, the vapor pressure has increased until it is equal to that of the atmosphere, and we are at the boiling point of the saturated solution. When we are carrying out our experiment in a closed tube, both the pressure and the solubility continue to increase past the boiling point, but unlike the solubility the vapor pressure of the saturated solution reaches a maximum, then falls. That this must needs be so is easy to see. The solubility curve, and hence also the vapor pressure curve, go from the cryohydrate point to the triple point of KNO_3. As at the latter point the vapor pressure is that of KNO_3 at its triple point, the curve, which, as we know, first rises, must reach a maximum and then fall to almost zero. We have in the case of vapor pressure two opposing tendencies. With increase in temperature the solubility of KNO_3 increases, and this tends to decrease the vapor pressure of the solution. On the other hand, the vapor pressure tends to increase because of the increase in temperature of the solution. With the less concentrated solutions the latter effect predominates, and the curve showing the change of vapor pressure with temperature, the P-T curve, rises. As the solution becomes more concentrated a point will be reached, when, because of the small proportion of H_2O in the saturated solution, the former effect becomes first equal to, then greater

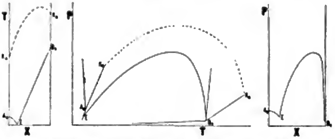

FIG. 2.—PROJECTIONS ON THE THREE BOUNDING PLANES OF THE SOLID P-T-X MODEL FOR AN IDEAL BINARY SYSTEM, IN WHICH NO COMPOUNDS ARE FORMED.

than, the latter, and the P-T curve will rise to a maximum, then fall.

We have, then, in a two-component system the three variables, pressure (P), temperature (T), and composition. These can all be represented by a solid model, in which the variables P, T, and composition (X) are represented by the *y*, *z* and *x* axes respectively, and probably the best way to consider the P-T and solubility curves is as projections of such a model on the appropriate one of the bounding planes. Figure 2 shows three such projections. The first is the solubility or T-X projection; the projection of the solid figure on the temperature-concentration plane. A_s is the triple point of the more volatile component, A; B_s, the triple point of the less volatile component, B. The next curve is the P-T curve, the projection on the pressure-temperature plane. A_s is the triple point of A; the curve A_sKA is the vapor pressure curve of pure liquid A; the curves A_sE and EB_s the P-T curves of the solutions saturated with solid A and solid B respectively. From the triple point the pressure falls to the cryohydrate at E, then rises; the branch EB_s in the two figures correspond. The latter curve first has a positive slope, which diminishes to zero, and is followed by a portion of negative slope, ending at the triple point of B. The third projection is the P-X projection, the projection on the pressure-concentration plane. The pressure falls from the triple point A_s of the more volatile component to the eutectic, then on further addition of B it rises to a maximum, then falls to the pressure at the triple point of B. These projections give the general relations which we meet with in binary systems whose components differ greatly in volatility and in which no compounds are formed. The system H_2O-KNO_3 is an excellent example, as are also several other nitrate-water systems. Unfortunately, only two of these have been studied quantitatively, H_2O-KNO_3, and H_2O-$AgNO_3$, and only in the latter case have both the P-T and T-X curves been determined. The maximum pressure in the system H_2O-$AgNO_3$ is at 1.4 atm. and 170°.

THE "SECOND BOILING POINT" OF SATURATED SOLUTIONS

There is an interesting circumstance connected with this maximum pressure. As we see, the P-T curve rises to a maximum, then falls. As we heat a saturated solution we pass along the ascending portion of the P-T curve, and, if we are working under the appropriate conditions, when the vapor pressure reaches one atmosphere the solution boils. Here we have a boiling point which is reached on heating a solution, and at it on the addition of heat the reaction

$$L = S + V$$

takes place. But if we draw a horizontal line at the height of one atmosphere we find that it cuts the P-T curve in two points, one at much higher temperature and higher salt concentration than the other. This latter is the second boiling point, first realized by Smits.* This second boiling point may be realized by cooling the solution. At it, on addition of heat, the reaction

$$S + V = L$$

takes place. The "spitting" of silver on freezing is a familiar example of the second boiling point.

THE MELTING OF SALT HYDRATES

We have just considered the case that no compound is formed between the solvent and solute, and have seen

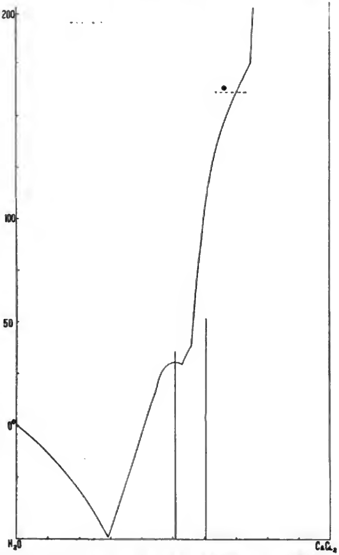

FIG. 3.—T-X CURVE IN THE BINARY SYSTEM H_2O-$CaCl_2$. PARTLY SCHEMATIC.

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* A. Smits, Vers. Akad. Wettenschappen, Dec., 1901.

that the solubility curve in systems containing a volatile component and the melting point curve in systems composed of non-volatile components are completely analogous. Let us now consider the case of formation of compounds.

As an example let us consider the system H_2O-$CaCl_2$. In this system several compounds are met with, and the system has been followed over a considerable temperature range. Figure 3 is a diagrammatic representation of this system. The cryohydrate is at about —55°; above this the hydrate $CaCl_2.6H_2O$ is stable. This compound is stable until the quadruple point $CaCl_2.6H_2O$-$CaCl_2.4H_2O$-liquid-vapor is reached, at 39.2°. It will be observed that this solubility curve rises to a maximum, then falls. On one side, $CaCl_2.6H_2O$ exists in equilibrium with liquids containing more H_2O than the solid phase, on the other, with liquids containing less H_2O; addition of excess of either of the components, H_2O or $CaCl_2$, lowers the melting point. It will be observed that here also a complete analogy exists between systems containing a volatile component, and systems containing only non-volatile components; we will later consider a point of difference.

From the quadruple point we have a new branch of the solubility curve, along which the temperature also rises, and along which the compound $CaCl_2.4H_2O$ is stable. This curve ends at the quadruple point $CaCl_2.4H_2O$-$CaCl_2.2H_2O$-liquid-vapor, where a new solid phase, $CaCl_2.2H_2O$, makes its appearance. This quadruple point differs from the preceding in an important particular. At the 6-4 quadruple point, the liquid phase contains less H_2O than the compound $CaCl_2.6H_2O$; the former can exist in equilibrium with a liquid of its own composition, *i.e.*, has a congruent melting point. At the latter quadruple point the liquid contains more water than the solid phase $CaCl_2.4H_2O$, and this phase cannot exist in equilibrium with a liquid of its own composition; it has an incongruent melting point. When the former compound is heated it will melt completely; the latter decomposes on heating with formation of a liquid phase and a lower hydrate, $CaCl_2.2H_2O$. Such incongruent melting points are very common; similar incongruent melting points or transition points are met with in systems composed of non-volatile components.

When we consider the projections of the solid P-T-X model of the case of a congruent melting point, we get the diagram shown in Fig. 4. Curve AQB is the melting point curve or solubility curve of the compound AB, ending at the quadruple point Q; from this point we have the melting point curve of the pure or anhydrous component B. In the P-T diagram, the pressure increases from the eutectic to a maximum, then decreases with increasing temperature, until a point of maximum temperature on the melting point curve is reached. The slope of the P-T curve then becomes positive again, and both pressure and temperature fall until the quadruple point is reached. From here we have the P-T curve of the equilibrium $B + L + V$, which is similar to the H_2O-KNO_3 case.

Proceeding from the quadruple point, besides the two curves giving the change of pressure with temperature of the saturated solutions, the univariant system solid-liquid-vapor, we have two other curves, neither of which is shown in the figure. One of them is the dissociation pressure curve of the hydrate, the P-T curve of the univariant equilibrium $AB + B + V$. It goes from the quadruple point to regions of lower temperature and pressure. The other curve gives the change in eutectic temperature with pressure; it is almost vertical, and as a rule both temperature and pressure increase along it.

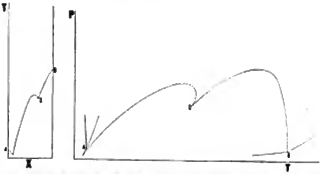

Fig. 4.—PROJECTIONS OF THE SOLID P-T-X MODEL FOR AN IDEAL BINARY SYSTEM IN WHICH A COMPOUND HAVING A CONGRUENT MELTING POINT IS FORMED.

At a temperature near the maximum,* hence to the left of the point Q, the liquid and solid phases will have the same composition; this is the lowest temperature at which a solid phase can exist in equilibrium with a liquid of its own composition, and is known as the "minimum melting point" of the compound. The melting point curve of the compound, the curve showing the change in melting point of the compound with pressure in the two-phase equilibrium $S + L$, is tangent to the solubility or fusion curve at the minimum melting point.

The case of an incongruent melting point can easily be conceived by imagining the solubility curve of anhydrous B to cut the solubility curve of AB at a point to the left of the minimum melting point of AB.

THERMODYNAMICS OF MELTING POINT CURVES

Let us return to the case of a congruent melting point (Fig. 4). So far we have considered the phase relations from a purely graphical point of view, and have not mentioned the fundamental thermodynamic considerations which govern the shape of these curves. The subject of heterogeneous equilibria is treated in a masterly fashion by Willard Gibbs in his great paper, "On the equilibrium of heterogeneous substances." From the equations derived there we may obtain,† by methods so simple that we must consider it to be implicit in his work, the equation:

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* The exact location of this point will be discussed later.

† Williamson and Morey, J. Am. Chem. Soc., 40, 49-59 (1918). Morey and Williamson, J. Am. Chem. Soc., 40, 59-84 (1918).

$$\frac{dP}{dT} = \frac{\eta^v - \eta^l + \frac{x^l - x^v}{x^s - x^l}(\eta^s - \eta^l)}{V^v - V^l + \frac{x^l - x^v}{x^s - x^l}(V^s - V^l)}$$

or, to put in the heat changes instead of entropy changes,

$$\frac{dP}{dT} = \frac{1}{T}\,\frac{\Delta H^{vl} + \frac{x^l - x^v}{x^s - x^l}(\Delta H^{sl})}{\Delta V^{vl} + \frac{x^l - x^v}{x^s - x^l}(\Delta V^{sl})}$$

In these equations, the exponents *v*, *l*, and *s* refer to the vapor, liquid and solid phases respectively, and the *x*'s refer to the mol fraction solute. ΔH and ΔV refer to the so-called differential quantities. For example, ΔH^{sl} is the differential heat of solution of the solid in the saturated solution; the heat change which takes place when 1 mol of the solute dissolves in a very large amount of the almost saturated solution.

If we apply this equation to the P-T curve along which the hydrate AB is stable, we get the following results. In the numerator the quantities ΔH^{vl} and ΔH^{sl}, the heat of vaporization and of solution or fusion, are not very different in magnitude, the former being, as a rule, 5 to 10 times the latter; and they are opposite in sign, the latter being negative. In the denominator, the quantity ΔV^{vl} is very large and positive, while the quantity ΔV^{sl} is small and, in practically all cases, negative. Now the last term in both numerator and denominator is affected by the coefficient $\frac{x^l - x^v}{x^s - x^l}$. The mol fraction of component B in the vapor is very small or zero, since the volatility of solute is small; the mol fraction B in the compound AB is 0.5. Hence, near the cryohydrate point, where x^l is also small, this coefficient is approximately $\frac{x^l}{x^s}$, a positive fraction. Here the sign $\frac{dP}{dT}$ is determined by the first and larger terms, both of which are positive, and the P-T curve has a positive slope.

As the temperature is raised the mol fraction solute in the liquid increases. Hence the coefficient $\frac{x^l - x^v}{x^s - x^l}$ increases rapidly, as the numerator is increasing, the denominator decreasing. The effect of this is to make the second term in both numerator and denominator, the terms ΔH^{sl} *and* ΔV^{sl}, of increasing importance. The first of these, ΔH^{sl}, is not very different in magnitude from the term ΔH^{vl}; the latent heat of evaporation is but a few times larger than the latent heat of fusion. But in the denominator the term ΔV^{sl} is many times smaller than the term ΔV^{vl}; the volume change on evaporation is of a different order of magnitude from the volume change on fusion. Hence the increase in the numerical value of $\frac{x^l - x^v}{x^s - x^l}$ at first affects only the numerator. As its coefficient increases, the negative second term increases until it is equal to the first, and positive, term. The entire numerator is then zero, and the P-T curve has a horizontal tangent. A little beyond this point the numerator is negative, the denominator positive, and the P-T curve has a negative slope. On further increase in temperature, the liquid approaches the solid phase in composition, the denominator approaches zero, and the coefficient $\frac{x^l - x^v}{x^s - x^l}$ attains a very large value; so large that the second term in the denominator becomes numerically equal to the first term, the denominator becomes zero, dp/dT becomes infinite, and the P-T curve has a vertical tangent; this is the point of maximum temperature. On further increase in temperature both the numerator and denominator become negative, $\frac{dP}{dT}$ is again positive, and the P-T curve falls to the eutectic point.

By applying the above equation to any particular case, the exact course of the P-T curve can be determined. Conversely, knowing the slope of the P-T curve and the volume changes, the heat changes can be calculated. There is one additional point, which the equation brings out, which I wish to emphasize.

In all we have considered so far we have found only similarities between systems containing both volatile and non-volatile components, and systems containing non-volatile components only. In the case of two non-volatile components, the maximum temperature on the melting-point curve of a compound is always at the composition of the compound. This is not the case when one of the components is volatile, and we are not working at constant pressure. Consider our equation again. When liquid and solid have the same composition, it becomes

$$\frac{dP}{dT} = \frac{1}{T}\,\frac{\Delta H^{sl}}{\Delta V^{sl}}$$

which is the equation of the P-T curve giving the change of melting point with pressure of the condensed system. As we saw before, this point on the solubility curve of the compound is called the minimum melting point, and it is evident from the equation that the slope of the curve at this point can only be infinite, *i.e.*, the point where liquid and solid have the same composition can only be a point of maximum temperature on the solubility curve, when V^{sl} is zero. In general the quantity is negative, and the minimum melting point lies at higher concentrations of the non-volatile component than the point of maximum temperature. In other words, in systems containing volatile components the maximum temperature is displaced toward the more volatile component.

ILLUSTRATIONS: THE SYSTEM WATER–POTASSIUM SILICATE

We have now considered the most important cases of equilibrium between volatile and non-volatile components in which no critical phenomena make their appearance, and have found that in general the systems resemble completely those formed by non-volatile components, as illustrated by the analogy between the systems $LiNO_3$-KNO_3 and H_2O-KNO_3. We have seen that the processes of solution and fusion are in principle identical, and that when no compounds are formed the solubility or fusion curve is continuous from the eutectic or cryohydrate point

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to the melting point of the anhydrous component. But few examples of complete solubility curves have been worked out. Until recently, the only example has been the system H_2O-$AgNO_3$. While this has not been studied in detail, most of the T-X and P-T curves have been determined and the second boiling point has been located. In the case of H_2O-KNO_3, only the T-X curve has been determined, and the second boiling point located. In neither of these cases has the pressure been very high; as a matter of fact, it does not necessarily follow that the pressure must rise to a high value, even though a comparatively high temperature is reached. In the system H_2O-KOH, the maximum pressure is less than one atm.; a solution of KOH cannot be boiled to dryness at atmospheric pressure.

More complete examples are found in some of the binary systems in the ternary system H_2O-K_2SiO_3-SiO_2, which has recently been studied.* In the cases just enumerated, the salts have had low melting points, and very high pressures have not been reached. Figure 5 shows the T-X curves of the binary systems H_2O-K_2SiO_3 and H_2O-$K_2Si_2O_5$. The lower curve is the solubility curve of K_2SiO_3. In this case we have two compounds and the anhydrous metasilicate, and both of the hydrates have incongruent melting points. We see here that the critical temperature of water is without influence on the solubility curve. The upper curve is the solubility curve of $K_2Si_2O_5$. We have here one hydrate, $K_2Si_2O_5.H_2O$. Here, also, the critical temperature of water is without influence on the solubility curve. These curves were not followed to lower temperatures, because of the compounds being decomposed by water. Let us digress a moment to consider the case that the compound is decomposed by water.

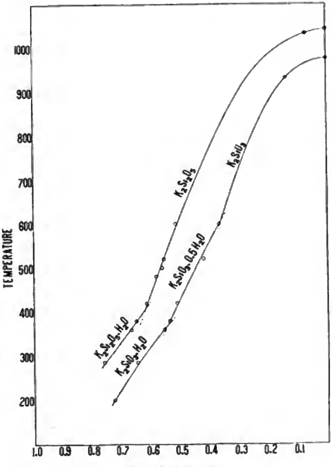

FIG. 5.—T-X CURVES OF THE BINARY SYSTEMS H_2O-K_2SiO_3 AND H_2O-$K_2Si_2O_5$.

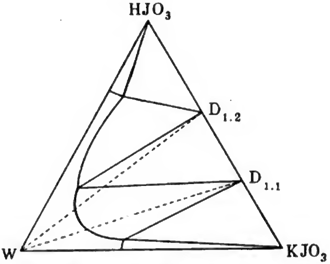

FIG. 6.—ISOTHERM IN THE TERNARY SYSTEM H_2O-HIO_3-KIO_3. W=H_2O; $D_{1.2}$=$KIO_3.2HIO_3$; $D_{1.1}$=$KIO_3.HIO_3$.

As we saw before, when we are dealing with a ternary system in which the solvent is a mixture of alcohol and water, it is necessary to specify the alcohol-water ratio; *i.e.*, to fix the composition of the solvent. If we are dealing with a ternary system such as water-KIO_3-HIO_3 (Fig. 6), similar restrictions must be made.† If we are dealing with a compound such as the acid potassium iodate, $KIO_3.HIO_3$, we may impose the restriction that the ratio KIO_3 to HIO_3 is the same in the liquid as in the solid phases, which is equivalent to assuming a binary system, or we may specify the KIO_3 to HIO_3 ratio. But when we speak of the solubility of the compound containing two molecules of HIO_3 to one KIO_3, $KIO_3.2HIO_3$, we find that it is decomposed by water. On adding this salt to water, when a solid phase appears it is not $KIO_3.2HIO_3$ but $KIO_3.HIO_3$; the acid-richer compound is only a stable solid phase in contact with solutions containing more HIO_3 than the solid phase. Hence to speak of its solubility in water is meaningless; we must specify the KIO_3-HIO_3 ratio in the solution. This is also true of the compound $K_2O.2SiO_2$ below 285°, and of $K_2O.SiO_2$ below + 180°. I have brought out this point to emphasize the

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* Morey and Fenner, J. Am. Chem. Soc., 39, 1173–1229 (1917).

† See the discussion of this point by Morey and Fenner, loc. cit.

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necessity of specifying enough conditions to make our statements precise, and this usually means to obtain an invariant system. In the case of a gas in water we do this by fixing the temperature and pressure. In the case of a binary salt-water system, we do this by fixing the temperature, and assuming that we are working either at the fixed pressure of one atmosphere or at the vapor pressure of the solution. In a system of more components it is necessary to define more variables.

These facts are evidently not realized by those who try to determine solubilities of minerals such as the feldspars in water at ordinary temperatures. Such minerals are decomposed by water; the end result, if equilibrium is reached, is an alkaline solution containing vanishingly small quantities of alumina, silica and lime, in equilibrium with a solid phase of a composition totally different from that of the original mineral. Such solubility determinations are meaningless; they are usually only rates of reaction under poorly defined experimental conditions.

THE APPEARANCE OF CRITICAL PHENOMENA

In all the cases we have considered so far, the solubility has been considerable. In the case of the H_2O-potassium silicate systems, we have seen that the solubility curves were followed up to over 1000°, far above the critical temperature of H_2O, and that the latter point was without influence on the solubility curve. When the solubility of the salt is small conditions may be very different. Let us examine the solubility curve of Na_2SO_4 in H_2O, as determined by Smits and Wuite.* Incidentally I must mention the fact that to Professor Smits of the University of Amsterdam is due most of our knowledge, theoretical and practical, of the interesting field which we are about to consider.

Figure 7 shows the solubility curve of Na_2SO_4 in H_2O from zero to 360°. We are all familiar with the lower portion of this curve; curve AB is the ice curve; point B, the cryohydrate; curve BE is the solubility curve of $Na_2SO_4.10H_2O$, ending at point E, the transition point of the 10-hydrate, *i.e.*, the quadruple point $Na_2SO_4.10H_2O$-Na_2SO_4-L-V; curve DRFF the solubility curve of anhydrous Na_2SO_4. At first the solubility curve of Na_2SO_4 is retrograde; the solubility first decreases with temperature, but then it passes through a point of vertical tangency and becomes normal. At F we have another quadruple point, at the transition from rhombic to monoclinic Na_2SO_4. The solubility curve of the latter is retrograde throughout its course, and at the critical temperature of water the solubility has become so small that the critical point of the latter is unaltered. The concentration at point P has been greatly exaggerated in order to make plain the relations existing there. The curve HP is the solubility curve of Na_2SO_4 in the vapor phase, which in reality will practically coincide with the H_2O axis. But, as we shall see later, at the critical temperature of the solution it is necessary that liquid and vapor phases have the same composition, hence they must flow together as shown.

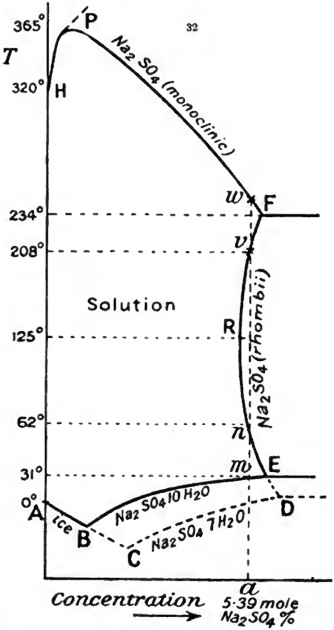

FIG. 7.—LOWER PORTION OF THE T-X DIAGRAM OF THE SYSTEM H_2O-Na_2SO_4.

This is in strong contrast to the cases previously considered, where with greater solubility no critical phenomena took place. There must be all gradations between the two cases; we will first consider the underlying causes of the formation of critical end-points, then some actual cases.

Consider again Figure 2, which shows the projections of the solid model for the case that critical end-points are not met with. The curve A_sKA is the vapor pressure curve of liquid A, ending at the critical temperature of A. Curve B_sKB is the vapor pressure curve of liquid B,

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* A. Smits and J. P. Wuite, Proc. Acad. Sci. Amsterdam, 12, 244 (1909).

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ending at the critical temperature of B. The broken curve represents the critical curve or plait-point curve of mixtures of A and B. It will be observed that addition of either component raises the critical temperature of the other. This is generally true, though the intermediate portion of the curve may have a more complicated form. The plait-point curve is continuous from critical point to critical point. In this case it lies wholly above the P-T curve; the critical phenomena are shown by unsaturated solutions only.

But suppose the solubility of the other component were small, so that the vapor pressure of the system became great, and the P-T curve of the saturated solution cut the plait-point curve. We then would have relations such as are shown in Figure 8; the lettering is the same as Figure 2. First observe that the plait-point curve is cut in two places by the solubility or fusion curve. The lower intersection gives rise to the first, the upper, to the second, critical end-point. Below the first, and above the second, critical end-points, critical phenomena are shown only by unsaturated solutions. At the two end-points the critical phenomena are shown by saturated solutions. At these points, then, we have equilibrium between a solid phase, and liquid and vapor phases identical in composition. Note that here the volatility of the second component, however small it may be, must be considered. In the case of Na_2SO_4, the curve H-P, which is greatly exaggerated in Fig. 7, shows the composition of the vapor phase, which becomes identical with the liquid phase at the critical end-point. In Fig. 8 we see similar effects at both end-points.

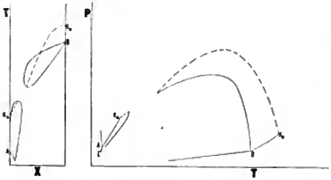

FIG. 8.—PROJECTIONS OF THE SOLID P-T-X MODEL FOR A BINARY SYSTEM HAVING CRITICAL END-POINTS.

We may look at these relations from another point of view. At the melting point of the non-volatile component, the volatile component exists as a gas. It will dissolve in the melt, and lower the melting point of the latter. The solubility of H and N in molten metals, *e.g.*, Ni, has been determined. If we have the gas under a pressure of 2 atmospheres, approximately twice as much will be dissolved by the non-volatile component, and a greater melting point lowering will be obtained. But we cannot continue this indefinitely; a point will be reached at which, no matter what pressure we put on, enough gas cannot be kept in solution to depress the melting point further; the saturated solution will show critical phenomena, and we will have arrived at the second critical end-point. Below this only solid and vapor phases are stable, until we reach the first critical end-point, when a liquid phase again becomes stable.

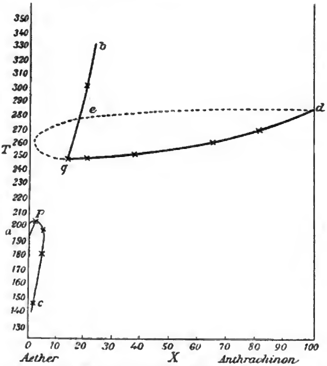

FIG. 9.—T-X DIAGRAM OF THE SYSTEM ETHER-ANTHRAQUINONE.

Only one example of systems of this type has been worked out, the system ether-anthraquinone, studied by Smits.* Figures 9 and 10 show the experimentally determined T-X and P-T curves. Curve *cp* is the lower portion of the solubility curve of anthraquinone in ether, curve *qd*, the upper portion. At the critical end-points *p* and *q*, the liquid and vapor phases become identical in composition. In the P-T curve (Fig. 10) the upper

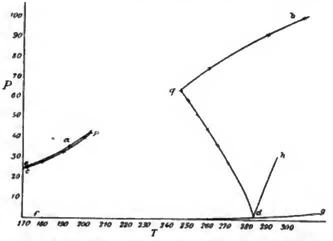

FIG. 10.—P-T DIAGRAM OF THE SYSTEM ETHER-ANTHRAQUINONE.

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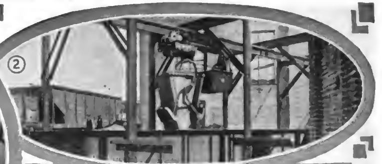
* A. Smits, Proc. Akad. Wettenschappen, 1911, 191.



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curves, *ca* and *gb*, are the two portions of the plait-point curve, the lower curves *cp* and *gd* the two portions of the solubility curve.

While this is the only case which has been worked out, the occurrence of critical end-points is common. Such systems are of first importance in geochemistry, where we have magmas composed of volatile and non-volatile components, under pressures sufficient to prevent the volatile components from escaping. One conclusion from which we cannot escape follows from the fact that at the critical end-point liquid and vapor have the same composition. There is no doubt that at the first critical end-point these phases are practically all water, in the case of most mineral systems composed of water and the predominating constituents of intrusive magmas, *e.g.*, quartz and feldspar. But the same is probably true of the second critical end-point; it does not seem probable that we can have a vapor phase containing any large proportion of anorthite, for example. If we grant this possibility, that the proportion of water at the second critical end-point is very large, it also follows that the temperature must be comparatively low; the second critical end-point must lie at a temperature not far above the first.* We then will have a continuous melting-point curve in the system H_2O-anorthite from the melting point of the latter—1550°—down to comparatively low temperatures, say, 400° to 500°. That is one of the subjects at present being studied—or was before the war—and preliminary results showed that the upper portion of the curve is capable of experimental verification. It may be of interest to know that molten anorthite, $CaO.Al_2O_3.2SiO_2$, dissolves enough water at one atmosphere pressure to decrease its melting point 5°.

THE DETERMINATION OF SOLUBILITY AT HIGH TEMPERATURE AND PRESSURE

The experimental study of solubility under high temperatures and pressures is a matter of great experimental difficulty. The combination of pressures of hundreds, or it may be, thousands, of atmospheres, at temperatures from a red-heat to over 1000° is indeed a formidable one, and to it must be added the corrosive action of the volatile component. The simplest method of studying solubility under pressure is to seal known quantities of solvent and solute in glass or fused silica tubes and heat, observing the temperature at which the solvent disappears. This is the standard method, the one used by Guthrie with KNO_3, and by Smits and Wuite with Na_2SO_4. This method is not well suited to high temperatures, especially with silicate systems. It is difficult to use a container which is one of the components of the system being studied, as is the case with glass or silica. Also, it is necessary to determine the vapor pressure of the solutions, or guess at it,

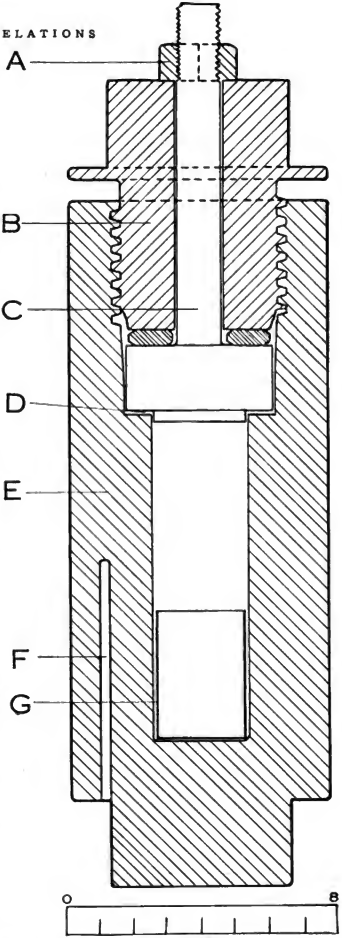

Fig. 11.—CROSS SECTION OF BOMB USED FOR HYDROTHERMAL EXPERIMENTS.

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* In the multi-component systems met with in nature the relations will of course be more complicated, but those complications can not be discussed here.

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in order to correct for the amount of solvent in the vapor phase. This correction is small at low temperatures, but as the vapor pressure increases it becomes increasingly important.

A method of study which has been applied successfully to the alkaline silicates, aluminates and ferrites consists in heating the charge in bombs of the type shown in Fig. 11. The bomb consists of three parts, the body, E, the plunger, C, and the screw plug, B, all made from tool steel. The closure is effected by means of a copper, or, at high temperatures, a gold or silver washer, D, held in place by the plunger and screw plug. The bombs, as a rule, are not lined, but the charge is placed in a gold crucible, G, in the bottom of the bomb.

The method of using this apparatus for quantitative solubility determinations is as follows:* The weighed charge is placed in the crucible, heated to the temperature of the experiment, and left until equilibrium is attained. The bomb is then removed and chilled by plunging into water. The crucible is then removed, weighed, and examined under the microscope.

When the charge is at the temperature of the experiment, its condition depends on its composition. If enough H_2O is present to dissolve all the solid material, and at the same time saturate the vapor space at the temperature of the experiment, the charge in the crucible will be all liquid. If the amount of H_2O is diminished below this, all the solid phase will not be dissolved; we will have a mixture of crystals and liquid. Now by chilling the melt it is possible to freeze the equilibrium, and by examination of the cooled charge one can tell whether or not the amount of water present was sufficient to dissolve all the solid phase. By varying the amount of water, the exact amount necessary to add in order to dissolve the known amount of solid material can be determined. By weighing the crucible, containing the known weight of non-volatile material, after cooling, one can determine the composition of the saturated solution; a point on the solubility curve of the compound. Knowing the amount of water added and the amount in the liquid phase, the difference gives the amount in the vapor phase. Knowing the temperature and the volume, the pressure can then be calculated.

Bombs of this type have been used in over three thousand experiments, and under a wide range of temperatures and pressures. Below 500° C. they last indefinitely, and remain tight under all the water vapor pressure that can be developed—I say water vapor pressure because obviously one dare not put so much water in a bomb that it will be completely filled with water below the critical temperature. But pressures as high as 400 atmospheres have been held at 600°, and experiments have been successfully carried out at 700° and 100 atmospheres pressure.

By this means, a number of systems have been studied, more or less completely. Most of the work is still unpublished. In the only system published, the system H_2O-K_2SiO_3-SiO_2, a number of new compounds were obtained, their properties determined, and the equilibrium relations of the system worked out. With the other alkali silicates the work has not been completed; the existence of a number of compounds, more or less similar in type to the potassium silicates, has been shown and their equilibrium fields in part outlined. The work on the alkali aluminates has been interesting in proving the existence of a number of compounds, many of which form well-developed crystals. One of these is the anhydrous monopotassium aluminate, $K_2O.Al_2O_3$, which crystallizes beautifully in large octahedral crystals. A similar compound has been found to exist in the system H_2O-K_2O-Fe_2O_3-monopotassium ferrite, $K_2O.Fe_2O_3$, which forms well-developed octahedral crystals, of a beautiful reddish color. Unlike the monopotassium aluminate, monopotassium ferrite forms no compounds with water, and is decomposed by water below 500° C.

This method of studying solubility or fusion relations is applicable only to cases in which the solubility is great enough so that liquid solutions can be obtained at not too high pressures, and in which crystallization is sluggish enough to permit the use of the quenching method. Another method has been developed which can be extended to regions impossible to study by any other means. The theory on which it is based is evident from a consideration of Figure 12, which should be compared with Figure 2. When we place a solvent and solute, in known proportions, in a closed vessel, so designed that the vapor pressure can be measured, we see from this curve that as long as we have present excess solid phase the P-T curve we obtain will coincide with the P-T curve of the univariant equilibrium solid-liquid-vapor. For example, if we start with a mixture of the composition given by point 1 of

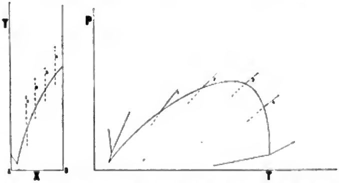

FIG. 12.—DIAGRAM ILLUSTRATING THE METHOD OF DETERMINING THE SOLUBILITY, I.E., THE T-X CURVE, FROM VAPOR PRESSURE MEASUREMENTS, I.E., THE P-T CURVE.

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* See Morey and Fenner, loc. cit., for a detailed discussion of this method of solubility determinations.

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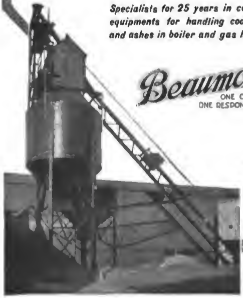

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the T-X curve and heat, we will follow the P-T curve of the saturated solutions until the temperature is reached at which the solid phase disappears. At this point the pressure-temperature curve obtained will show a change in direction; the P-T curve of the change in vapor pressure with temperature of the unsaturated solution. By determining a series of such P-T curves, with increasing proportions of solute, we will obtain a P-T curve such as is shown in Fig. 12. The temperature at which the solid phase disappears in each case can be found from the curve, being given by the point of intersection† of the P-T curve of the unsaturated solution and the P-T curve of the univariant solution and the P-T curve of the univariant equilibrium solid + liquid + vapor. Hence we know the temperature at which each known amount of solvent will just dissolve the known amount of solute, the melting temperature of each mixture. The method has worked well in practice. The location of the intersection of the two curves is facilitated by the ease with which solutions become supersaturated; on cooling this solution it may almost invariably be cooled well below the 3-phase curve, as shown by the dotted lines, and hence we have a very definite intersection to locate. This work, as has all the research work in our laboratory, has been interrupted by the war.

SUMMARY

To summarize, we have seen that solubility curves can be divided into two classes, those in which the solubility curve intersects the plait-point curve, and those in which there is no such intersection. We have seen that in the latter case the solubility curve is continuous from the eutectic or cryohydrate point to the melting point of the anhydrous component, and that there is no distinction between solubility and fusion curves, and that no outstanding distinction can be made between solvent and solute. In this case the critical point of the solvent is without influence on the equilibrium relations. When the solubility curve intersects the critical curve, two critical end-points are found. Below the first, and above the second, critical end-point, the relations are similar to those in the first case. At the critical end-point the saturated solutions show critical phenomena, and liquid and vapor phases have the same composition. Lastly, we have considered some methods for the experimental study of solubility or fusion relations at high temperatures and pressures.

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† That the two curves are not tangent, but intersect, can be readily seen from a comparison of the slopes, $\frac{dP}{dT}$ in each case

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ENGINEERING AS A FORCE IN PHILADELPHIA'S PROGRESS *

By **J. FRANKLIN STEVENS**

President Engineers' Club of Philadelphia

THE value of Philadelphia's location, lying as it does between the great natural resources of central Pennsylvania and the sea, has been often discussed, but too little attention has been paid to the value of the services which her citizens have rendered in taking full advantage of her favorable location.

Lying immediately west of us we have the largest and most valuable coal fields in the world, together with vast agricultural and mineral resources; within our city limits we have two great rivers giving direct access to the sea and every facility at hand, or susceptible of development, for a great shipping port for overseas and coastwise trade. These natural advantages have already made us the greatest manufacturing city in this country, and if we are prepared to take advantage of them, will maintain us in this position and likewise will make us one of the great shipping ports and mercantile centres.

In the development of our present position no single force has been greater than that of the engineering profession, for it first developed our mines and other natural resources, planned and constructed the railways to bring these resources to us, designed and erected the factories in which natural resources are transformed into manufactured products, and designed and built the ships and port facilities whereby the finished products may be transported. No class of men, professional or non-professional, has been so closely identified with or so great a force in Philadelphia's progress in the past, and no force can be more confidently counted upon to assist in her future progress.

The unusual conditions imposed upon us by the war and the response made by the engineers of Philadelphia illustrate the effectiveness of this force and give great promise for the future. The story of engineering accomplishment is being written in the records of the Engineers' Club of Philadelphia and later on will be incorporated as an important part in the history of Philadelphia's progress—past, present, and future.

This Club, which is the representative organization of engineers in Philadelphia, has an active membership of about 2000, with an additional affiliate membership of 1500. Already it has contributed some 300 members to the national defense, its members holding rank from private to Brigadier General in the Army and from sailor to Rear Admiral in the Navy, while, almost without exception, the remaining members are actively engaged

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* Reprinted from "The Corn Exchange," September 28, 1918.

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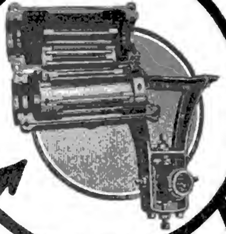

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The engineering profession as it stands today is a striking example of progress, and its history is ample warrant that it is prepared to perform its part in the progress of the future. Well within the memory of present-day engineers is the engineer of a former generation, an outgrowth from the physicists and philosophers of old, narrowly educated, purely technical, strictly applying the laws of nature to the use and benefit of mankind. To-day the modern engineer is a man of broad and liberal education, versed in history and the liberal arts, trained in political economy and psychology, experienced in commerce and finance, and as such is prepared to take his place among men of affairs, capable of directing the affairs of city, state, and nation. The purely technical side of engineering, investigation, research, invention, and construction is still essential and necessary to progress; but the same mind must be capable of carrying through the conceived project to the accomplished reality. So then the engineer serves his apprenticeship in the purely technical side of his work while he learns in the school of practical business and finance the lessons which enable him to assume the position of technical adviser to capital. Through him capital can learn the proper avenues for investment in the development of our natural resources and can predict with certainty the returns sure of attainment under proper (and usually this means engineering) supervision and direction. Through and with the assistance of capital the engineer can apply the laws and resources of nature to the use and benefit of man. Each, without the other, is incomplete, an uncoordinated force; together, they make for progress in art, science, and civilization, for all that is worth while in our modern civilization as it is and as it will be.

Engineering has been a great but unappreciated force in the progress of the world; upon its work has been built the civilization of to-day, and in its hands lies the best promise of the future. Give to the engineer the essential tool of capital, place in his hands the direction of his own inventions, and the world will see a progress in the future compared with which the achievements of the past will seem small and unimportant.

What the engineering profession is prepared to do for the world as a whole the engineer of Philadelphia is prepared to do for his own city, asking only that he be given the whole-hearted coöperation of the financial, industrial, and commercial interests. He can and will demonstrate that Engineering is a Force in Philadelphia's Progress.

TRAINING CHILDREN IN SAFETY

By LAURA M. ROADEFER

Director of Safety Education, Philadelphia Rapid Transit Co.

TO those who are lovers of little children, it seems unnecessary to argue the need for their "safety" education for any other reason than the humanitarian one; but military and industrial leaders have, particularly during the last two years, voiced their opinions of the necessity for safety education for the children of America, from the "economic" view, with a seriousness that is shared by everyone who has the welfare of the nation at heart. Men and women all over the country are giving themselves to the work among the children, realizing that they are the coming nation, for the good of which America is at war.

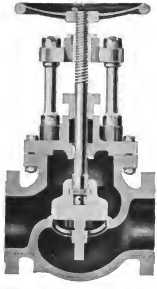
President Wilson, in his letter to the "Children's Bureau," in which he expressed his approval of the plan to dedicate this year, the second year of America's entry into the war, to the children: "Next to our duty to the soldiers at the front, there is no greater duty, it seems to me, than that to the children of America who constitute one-third of the population." And it is a patriotic duty to centre the attention on the strength and safety of young lives in order that America may have a strong and hearty generation to spring into the ranks of the men who have fallen.

Every child reaches the age when his well-being lies in his own hands, and he must be taught the importance of regarding his own safety as the property of the country which he loves, the true meaning "Safety-first slogan," and the actual disloyalty of endangering his life needlessly.

Military leaders claim that much of the work in the training camps could have been greatly simplified had our men been trained along the scorned "safety-first" lines in earlier years.

Industrial leaders have proved how amazingly successful are the results from safety education, in both economic and social ways, among the men and women in their plants, and realize that more beneficial results can be expected if the future workers are trained to safeguard themselves before they are ready to enter the mills and factories. Even now, in these war-time days, we are bracing ourselves against the time when so many of the children about us will be facing the hazardous inventions in modern industry.

It is, however, a rather difficult matter to instil this "Safety-first" idea in an attractive form into the reckless souls of Young America. From all appearances, the one high aim of these active boys and girls is to see how many bones can be broken in the short course of one dauntless life. The boy who hesitates to assail the topmost twig of the highest apple tree is a 'fraid-cat, effeminate, and his life becomes ashes. He is an outcast from the ranks of his fellows. No self-respecting little American girl, who wishes to hold her prestige in her small



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Note the navy yoke with finished steel columns and handwheel and the swing-bolted stuffing box.

Stem is rolled monel with special acme threads for maximum strength, long wear, and ease of operation.

The regrinding and renewable monel disc has leader to clean seats and prevent wire drawing.

Monel seat ring is screwed in heavy steel bridge, with disc guide strongly braced by spider arms.

Bonnet flanges are finished on edges and have male and female faces to insure perfect alignment.

Through bolts are used on all parts of valve.

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Valve can be packed when open.

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An Ohio Manufacturer Says:—

"I would have no other make."

ONE reason is, his Yarway Seatless Blow-Off Valves have been in service three years without leaking and without being repacked. Read his report.

Other equally favorable comments have been received from Ohio, where many Yarway Blow-Off Valves are in use by such industries as

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National Cash Register Co.	**24**	"
Cleveland Electric Illuminating Co.	**178**	"
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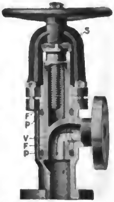
Willys-Overland Co.	**13**	"
Procter & Gamble Co.	**157**	"
Toledo Ry. & Light Co.	**24**	"
Carnegie Steel Co.	**20**	"

There are no seats or discs in the Yarway. The port is large and unrestricted. Packing is so protected that it will last two or more years without renewing. And the Yarway is safe and certain in operation.

Try one for 60 days subject to return.

State size of line and whether screw or flange, angle or straightway.



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YARWAY Starting and Pressure Unloader (Richards Patents)

YARWAY
SEATLESS *formerly* *(SIMPLEX)*
BLOW-OFF VALVE

social circles, could endure to fall behind her masculine acquaintances in daring feats.

The natural courage of these little Americans is also the natural source of recklessness, and to show them that recklessness is not bravery is the first step to take in instilling in them some regard for their own safety. Hero worship, the quick pride and enthusiasm which they feel, when the story of some sublime piece of recklessness of the American soldier in battle, fills them with scorn at the idea of self-preservation, and they do not realize that the brave man, the leader in battle, guards himself carefully for the sake of the other men under him or beside him, until the moment comes when he must obey the law of higher discretion.

The subject of Safety-first is, then, fundamentally unattractive to the boy or girl whose natural impulses are to steal a ride on the back of the ever-popular ice-wagon, and whose earliest hero is the tight-rope walker, or the "human fly." Thus, the psychology of the child's mind has to be carefully considered in order to present the idea in an acceptable light.

According to "Natural Education" methods (Mrs. Winifred Sackville Stoner), it is argued that just as the disagreeable dose in the doctor's prescription can be pleasantly taken and digested when submerged in something we really like, so the dry, uninteresting subjects in the school curriculum can be unconsciously taken and mentally digested when appropriately combined with something which is especially interesting to the normal mind.

"How to interest your employees in Safety First" has been the topic for discussion in hundreds of Safety Council meetings; and it is usually concluded that one of the most successful ways is by illustrating with pictures, the dire results of unmindfulness of "Safety."

For example, a picture of a workman throwing a lighted match into a barrel of ignitable explosive followed by a picture of the same individual mounting the heights to a premature heaven, etc., have produced the desired psychological effect on the minds of adult employees.

But adult psychology and child psychology are as different in their application as in their theory, and such pictures as these shown to children, particularly to the supersensitive, would excite "fear" rather than "caution," which is an effect decidedly to be avoided. It is true that pictures impressed on the mind of child or adult, either by words or by the brush, leave deeper impressions than any long, reasonable argument. But care must be taken that these pictures do not suggest anything gruesome or repulsive to the children; however, according to the "law of contrast," the child can and should be made to realize the contrast between the "strong and the crippled," the "well and the sick," but this can be accomplished without crowding the subject with unhappy thoughts.

Every normal child loves a story; from the "Little Pig Went to Market" stage, up through the "fairy" tale, and into the tales of "adventure" and "heroism," there are unlimited possibilities for the story-teller to paint her pictures with the "Safety" objective for her high lights.

Once the imagination of a child is colored with a new view of the "Safety" idea, it is not hard to incite him with an interest in putting his new ideas into practice. To do this, it is essential that he be brought to a thorough realization of his individual responsibility and to see the importance of his own safety from a patriotic standpoint. When this can be done, real progress has been made.

In Philadelphia, we have organized "Safety patrols" among the school children. Members have been made to feel that they are responsible, not only for their own safety, but also for the safety of the younger children, and individual responsibility is doubly strengthened when a child realizes that he is and always must be, in some sense, "his brother's keeper."

Letters from school principles express their appreciation of the merited work accomplished by the patrols in reducing the number of preventable accidents among school children. Indeed, so far from reducing a child's natural bravery, this new responsibility leads to a thoughtfulness which is the foundation of great courage.

Last year, a "Junior Safety Council" was organized, consisting chiefly of the Safety Patrol Members, to whom the Philadelphia Chamber of Commerce extended the privilege of meeting monthly in their Assembly Room Officers were elected and committees formed to investigate all dangerous localities in the school neighborhoods, and the Department of Public Safety offered to coöperate with the Council by erecting danger signs in those localities which were reported as unsafe by the investigators.

At these meetings of the Council, reports are read by the Captains of the Patrol Squads, and talks are given by different well-known speakers. Among the speakers scheduled for 1917–1918 were: Judge Brown of the Juvenile Court, Captain Merrill of Camp Meade, Private Jones of General Pershing's "Veteran" forces, and Mr. F. W. Johnson, one of the pioneer safety-first promoters in this country.

During the summer "Safety-First Leagues" were organized in the playgrounds, the children signing the pledges which read: "I hereby pledge myself as a member of the Safety-First League, to aid my Country and my City during this 'Children's Year,' 1918, in the endeavor to prevent accidents. First: By learning about and practicing Safety First. Second: By encouraging others to do likewise." The children signing were awarded little red, white and blue buttons by the Philadelphia Rapid Transit Company for "reminders," on which was printed: "The Safety-First League."

The first step has been made. Gradually the results have been developing. American children are beginning to realize that they are the servants of the nation, and that foolhardiness is merely a tinselled counterfeit of bravery.

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FUEL SUGGESTIONS

By GEORGE R. HENDERSON,
Engineer for Penna., United States Fuel Administration.

WITH the approach of the winter season and its attendant serious fuel situation, we feel that it is desirable that every one should be acquainted with the task of the Fuel Administration and what it is trying to do.

The Bureau of Conservation is endeavoring to save, by increased efficiency in operations, about 10 per cent. of the total industrial fuel consumption for 1917, and this is to be done without interference with the industrial production as it exists at present, and with increased output from manufacturers of war supplies.

The Fuel Administration has been depending upon the intelligent coöperation of manufacturers, without resorting to the arbitrary curtailment of coal supplies. If this method is to be continued, it is evident that every corporation burning coal must take immediate and energetic steps to reduce its consumption to the absolute minimum.

The returns from the questionnaire which has been sent over the State, correspondence, and meetings with various industries throughout the State of Pennsylvania indicate a splendid spirit of coöperation, and from reports that are at hand it is known that with the comparatively few plants we have actually so far investigated there will be a great saving over last winter. The worst offenders, as a rule, are the small plants, where coal has been to them an unimportant factor and the output of their manufacturing establishment of prime importance.

It must be borne in mind, however, that manufacturing would be impossible without coal, and it is of great importance that every one, therefore, take upon himself to see that care and attention given to the matter of fuel conservation which it rightly deserves, as otherwise there may be an insufficient amount of coal for the use of the industries, and many may have to curtail, if not abandon, their operations, owing to the expected deficiency for the coming winter.

The Fuel Administration is endeavoring to assist every one, both by means of bulletins, letters, and conferences; but as it is impossible to reach every one in the State by means of the questionnaire and by letters, it is urged upon all that immediate cognizance of this matter be taken up without waiting for the official questionnaire and rating, upon which the coal allotment may be based.

GASES USED BY THE HUNS

MAJOR S. J. M. AULD, in the Journal of the Washington Academy of Sciences, gives the following list of gases used by the Germans:

1. Allyl isothiocyanate (allyl mustard oil), C_3H_5NCS (shell).

2. Benzyl bromide, $C_6H_5CH_2Br$ (shell).

3. Bromaceton, $CH_2Br.CO.CH_3$ (hand grenades).

4. Bromated methyl ethyl ketone (bromketone), $CH_2Br.CO.C_2H_5$ or $CH_3CO.CHBr.CH_3$ (shell). Dibromketone, $CH_3CO.CHBr.CH_2Br$ (shell).

5. Bromine, Br_2 (hand grenades).

6. Chloracetone, $CH_2Cl.CO.CH_3$ (hand grenades).

7. Chlorine, Cl_2 (cloud).

8. Chlormethyl chloroformate (palite), ClCOO CH_2Cl (shell).

9. Nitrotrichlormethane (chloropicrin or nitrochloroform), CCl_3NO_2 (shell).

10. Chlorosulphonic acid, $SO_3H.Cl$ (hand grenades and " smoke pots ").

11. Dichlordiethylsulphide (mustard gas), $(CH_2Cl CH_2)_2S$ (shell).

12. Dimethyl sulphate, $(CH_3)_2SD_4$ (hand grenades).

13. Diphenylchlorarsine, $(C_6H_5)_2AsCl$ (shell).

14. Dichlormethyl ether, $(CH_2Cl)_2$ (shell.)

15. Methylchlorosulphonate, CH_3ClSO_3 (hand grenades).

16. Phenylcarbylamine chloride, $C_6H_5NCCl_2$ (shell).

17. Phosgene (carbonyl chloride), $COCl_2$ (cloud and shell).

18. Sulphur trioxide, SO_3 (hand grenades and shell).

19. Trichlormethylchloroformate (diphosgene, superpalite), $ClCOCCl_3$ (shell).

20. Xylyl bromide (tolyl bromide), $CH_3C_6H_4CH_2Br$ (shell).

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SERVICE LETTER BOX.

Paris, October, 1918.

The Committee on Publication:—

Your letter of August 30 is received, and I will try to comply with your request, assuming that you are especially interested in things and incidents that concern the engineering side of the war.

Between the starting points and the objectives of the first two days (September 12 and 13) of the American offensive in the St. Mihiel sector there was a belt of territory averaging seventeen kilometers in width. In the middle of the belt was what has been No Man's Land for nearly four years. There were no roads. There had been roads, but rifle trenches had been dug across them; tank trenches had been cut to a depth of above two meters and a width of perhaps five meters. What was left of the roads after four years of neglect and trenching was shelled to pieces by both sides before the advance began.

Nevertheless, it was over these destroyed roadways that the Americans must advance their supplies and guns. We were on the move Saturday, the offensive having begun at 1 o'clock Thursday morning. For ten miles there were uninterrupted streams of trucks, guns and gun carriages, travelling northward toward new divisional points and positions. There was little traffic toward the rear, only enough to complicate and delay the heavy movement forward.

It was up to the engineers to make the roads passable, in the first place, and keep them so. Shell holes were roughly filled with broken stone and covered with earth; it had rained for a week, and if a camion slipped off the road only a foot it sank hub-deep in mud and had to be pulled out. So the engineers went to work in scores of places widening the roads by the addition of two or three feet of stone from walls, demolished buildings, or wherever it could be found. Trenches and ditches were bridged by logs. It was rough work, but it got the traffic through somehow.

I left one divisional headquarters for another Saturday morning at 6 o'clock. By 9 o'clock it was evident that no automobile would get through that day, so I got out and walked along the line of trucks, some of which had been on their way for twenty hours. After dodging in and out and around autos and guns and carts for two or three miles, a staff car came along; but instead of a general or two, it contained Ray Carroll, correspondent of the Philadelphia *Ledger*, and Junius Wood, of the Chicago *News*, on their way to the advanced American positions. I climbed aboard, and, thanks to the red, white and blue insignia on the windshield, we covered the remaining ten miles in an hour and a half.

Along the road were the engineer corps, breaking stone, shovelling dirt, bridging holes and trenches; mud-covered and looking more like gangs of day laborers than engineers.

The engineers over here have done some big work, at ports, on railways, putting up huge shops, refrigerating plants, and what not. But at the front their job is a rough one. Their work isn't pretty, but it is indispensable, and is usually performed under conditions that at home would drive a construction man crazy.

Something of the spirit with which they go at it may be judged from this: One night in E——, after the Americans were well established at points ten or twelve kilometers further on, the Boches began shelling the road and the town. All traffic on the roads stopped at once. I was occupying a comfortable hole under the steps of a church, along with three engineers. As the traffic halted, one of the engineers remarked: "That's good; now we can get those damned shell holes on the way to St. B—— filled up before morning." And he crawled out to give the necessary orders to his squad.

Daniel T. Pierce.
Major, American Red Cross.

POSITIONS OPEN

Wanted: Chief Engineer to take charge of Power Plant. One who has had actual experience with regard to obtaining results in combustion with the aid of pyrometers, draft gauges, and gas-testing apparatus. Apply Engineers' Club, No. 251-A.

Wanted: Road Engineer, in Constructing Quartermaster's Department, U.S.A. Apply Engineers' Club, No. 252-A.

Ten young engineering graduates who desire to serve indirectly, are needed as instructors by the Aero Engines Division, U. S. School of Military Aeronautics, Austin, Texas. Teaching and gas engine experience are not required, but applicant must be energetic, adaptable and of unquestioned loyalty. Position carries deferred classification. Apply directly to Head of Division, furnishing data as to age, citizenship, education and experience.

Commissions open to experts in the following lines: Mechanical engineers with experience in safety engineering; ventilating engineers acquainted with the problems involved in the elimination of fumes and gases and the removal of trade dusts; chemists experienced in acid manufacturing plants or in power production; sanitarians who have had training or experience with industrial diseases and accidents. Apply Bureau of Public Health Service, Department of Industrial Medicine and Hygiene, Ouray Bldg., Eighth and G Sts., Washington, D. C.

Engineers and designers wanted. High-grade men for permanent work. Apply Engineers' Club, No. 254-A.

Wanted: Mechanical and safety engineer; two or three years' shop training; must have tact and be able to meet State officials and executives; $1800 to $2500. Apply Engineers' Club, No. 255-A.

POSITION WANTED

Mechanical and Civil Engineer, technical graduate; prefers position as superintendent of power or maintenance in Philadelphia. Write to No. 223, Engineers' Club.

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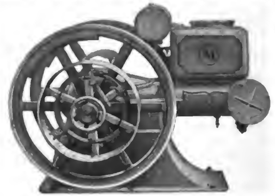

Here is a machine—You **see** it at a glance. It would take **pages of type** to convey an adequate idea of it.

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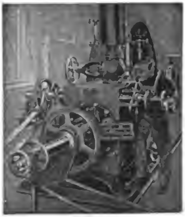

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COMMITTEE ON PAPERS

LEWIS H. KENNEY, CHAIRMAN

REGULAR MEETING

at Witherspoon Hall

Tuesday, November 19, 1918, 8.15 P. M.

MR. GEORGE W. BRADEN,

former Y. M. C. A. Director of Athletics and Recreation for the Italian Army, will present a paper, illustrated with lantern slides, entitled

"OVERSEAS EXPERIENCES IN ITALY"

Members of the Club and of affiliated societies are privileged to invite ladies to the meeting.

Mr. Braden will outline the place Italy has had in the war; her man-power and industrial mobilization; the needs of recreation for her army; athletics in Allied armies; coöperation of General Zuippelli, Minister of War, General Zaconi, the Chief of Staff, and General delle Valle, Director-General of Hospitals in Italy; coöperation of the Italian Red Cross; introduction of the American system of athletics and recreational sports; introduction of recreational sports in the Eighth Army (formerly the Second), which suffered the great collapse in the Fall of 1917 then in process of reorganization, with a view to raising its morale; the part prominent Italian women are taking in medical and war work; and the Italian Boy Scouts.

TUESDAY NOON LUNCHEONS

The following schedule of speakers has been arranged:

November 5	Major-General L. W. T. Waller, U. S. M. C.:—**"The United States Marine Corps."**
November 12	Mr. Philip Francis Nowlan, of the Public Ledger staff:—**"Sales Engineering."**
November 19	Mr. George S. Webster, Director, Dept. Wharves, Docks and Ferries:—**"The Port of Philadelphia."**
November 26	Mr. Charles N. Kight, accompanied by the Superintendent of the Aerial Mail Service, Washington, D. C.:—**"Aeronautics and the Aeroplane Service now in effect between Washington and New York."**
December 3	Dr. Lightner Witmer, Department of Psychology, University of Pennsylvania.
December 10	Mr. Thomas F. Armstrong:—**"Guilty or Not Guilty."**
December 17	Commander F. G. Coburn, U. S. N., Manager Naval Aircraft Factory, Navy Yard, Philadelphia:—**"Aeroplane Construction."**

COMMITTEE ON MEMBERSHIP

PAUL SPENCER, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before November 11 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO ACTIVE MEMBERSHIP

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Proposed by Charles Penrose and W. H. Connell.

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312 S. Tenth Street, Philadelphia, Pa.

Assistant Manager, Works Division, Chester Shipbuilding Corp.

Proposed by Dudley T. Corning and Edward T. Mendenhall.

ALVIN WARD KING,

108 E. Moreland Ave., Chestnut Hill, Philadelphia, Pa.

Sales Manager, Nelson Valve Company.

Proposed by D. Robert Yarnall and Jacob M. Noll.

FRED MYERS RYDER,

Care Keystone State Construction Company, Broad and Filbert Sts., Philadelphia, Pa.

Engineer, Keystone State Construction Company.

Proposed by Wm. P. Parker and S. M. Swaab.

FOR ELECTION TO JUNIOR MEMBERSHIP

ALFRED A. ADLER,

2009 N. Park Avenue, Philadelphia, Pa.

Testing Ship Machinery, Philadelphia Navy Yard.

Proposed by John L. Schultz and M. Alpern.

HARRY AARON BILLIG,

644 N. Fifteenth Street, Philadelphia, Pa.

Student Engineer, Bell Telephone Company of Philadelphia.

Proposed by J. D. Ferry and R. W. Welsh.

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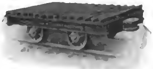

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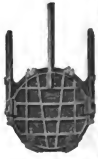

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SECRETARY'S NOTICES

A BUSINESS MEETING of the Club will be held on **Tuesday evening, November 19, 1918,** at 8.15 o'clock, at **Witherspoon Hall.**

The following were appointed by the Board at its Regular Meeting on October 8, 1918, to constitute the Committee on Nominations for the current year:

F. C. Dunlap, *Chairman*
W. P. Dallett
H. W. DuBois
H. P. Liversidge
George B. Taylor
William S. Twining
D. Robert Yarnall

In the absence of a Regular Meeting of the Club in October, due to the recent ruling of the Bureau of Health, this list is now submitted to the membership, and will be brought up for alteration or acceptance at the November 19 meeting, in accordance with Article V, Section 3, of the By-laws.

ABSTRACT OF MINUTES

of the Regular Meeting of the Board of Directors, held October 8, 1918.

The meeting was called to order at 7.15 P. M., with President Stevens, Vice-President Wagner, Directors Spencer, Swaab, James, Quimby, Past-President Ledoux, Treasurer Kenney, and Secretary Stockly in attendance. Vice-Presidents Andrews and Eglin, Directors Connell, Gant, Long, Lauer, Murphy, Lee, Douglas, Terrell, Newkirk, Barr, and Past-Presidents Carter and Vogleson were excused.

REPORT OF THE PRESIDENT

Mr. Paul Spencer has been appointed a member of the Executive Committee, vice Captain H. P. Gant, resigned.

REPORT OF THE SECRETARY

In accordance with Article V, Section 3, of the By-laws, the following were appointed to constitute the Committee on Nominations for the current year:

F. C. Dunlap, *Chairman*
W. P. Dallett
H. W. DuBois
H. P. Liversidge
George B. Taylor
Wm. S. Twining
D. Robert Yarnall

The Philadelphia Section, Association of Iron and Steel Electrical Engineers, have advised that Mr. Linn O. Morrow has been appointed to represent their Society on our Board of Directors.

In accordance with the By-laws, Article IV, Section 7, Mr. William Pool Parker was elected to fill the vacancy in the Directors-at-large caused by the election of the Philadelphia Section, Association of Iron and Steel Electrical Engineers, to affiliation, Mr. Parker's term to expire July, 1919.

Dr. Carl Hering was elected a Trustee of the Bond Redemption Fund, vice Dr. Edgar Marburg, deceased.

Resignations from the following members in good standing were presented and accepted:

B. B. Bachman
A. E. Clarson
Agnew T. Dice
George S. Emerick
Warren D. Fuller
R. E. Hasselgren
G. S. Wheatley
Staunton B. Peck
W. A. Manwaring
John A. Kelley, Jr.
Joseph M. Jameson
Lyle L. Jenne

The following deaths are announced:

Mr. James M. Africa, Active Member, died September 18, 1918.

Lieut. Richard F. Day, Active Member, died September 25, 1918.

Mr. W. A. Moncure, Active Member, died October 2, 1918.

Mr. G. M. Spear, Active Member, died October 4, 1918.

Mr. Henry S. Raub, Active Member, died October 8, 1918.

Mr. W. E. Herring, Active Member, died October 9, 1918.

A letter from Mr. F. K. Worley was presented, suggesting that the Club take measures to pay some recognition at Christmas-time to the men of Companies B and E, 103d Engineers, who have been in France since June.

After discussion, the matter was referred to the Committee on National Service, with the request that it be carried through if, upon further consideration, they deem it practicable.

The matter of a suitable service flag for the Club was discussed and referred to the Committee on National Service, with the request that they give consideration to ways and means of providing a new service flag and keeping same to date, as the number of members in service varies from time to time.

REPORT OF THE TREASURER

The Secretary presented a report on the financial condition of the Club, which was accepted.

REPORT OF THE COMMITTEE ON MEMBERSHIP

On the recommendation of the Committee, the following were elected:

To *Active* Membership:

George Elwood Button
Andrew M. Chesney
J. Parker B. Fiske
Isaac Stanley Walker

REPORT OF THE COMMITTEE ON PAPERS

The Committee presented a report, which was accepted by the Board, giving schedule of papers to be presented at meetings of the Club to and including January, 1919, and schedule of speakers for noon luncheons to and including November 19, 1918.

The meeting adjourned at 9.15 P. M.

H. A. Stockly,
Secretary.

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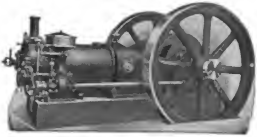

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GUILLIAEM AERTSEN, Chairman

> *"From these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion; these dead shall not have died in vain."*—Abraham Lincoln.

Barker, Edward Williams	Sergeant	Junior Member	Died March 17, 1918, Camp Meade, Admiral, Md.
Day, Richard F.	Lieutenant	Active Member	Died September 25, 1918, Clermont, France
Hetherington, S. C.	1st Lieutenant	Active Member	Died September 28, 1918, Argonne, France
Prichett, Frederick B.	Lieutenant	Active Member	Died September 6, 1918, France
Prince, Harry Walter	1st Lieutenant	Junior Member	Died June 11, 1918, England
Zeckwer, J. R.	Ensign	Active Member	Died October 15, 1918, Philadelphia

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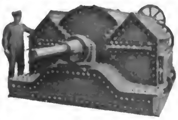
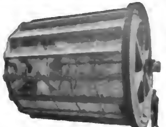
ADDITIONS AND CORRECTIONS TO LIST OF MEMBERS OF ENGINEERS' CLUB IN SERVICE, PUBLISHED IN THE OCTOBER JOURNAL

Andrews, J. H. M.	Lieut. Colonel	Ordnance Dept.	Care of Raritan Arsenal, Metuchen, N. J.
Bergman, G.	Private	Utilities Company, Quartermaster's Corps	Camp Dix, N. J.
Brewer, P. C.	Lieutenant	4th Regt., Engineers	Camp Humphreys, Va.
Brown, W. F.	1st Lieutenant	520th Engineers	American Expeditionary Forces, via New York
Carson, W. C.		32nd Service Co., S. C. School of Meteorology, Overseas Casuals	American Expeditionary Forces, via New York
Cleaver, D. C.	Private	Co. 10, 3rd Battalion, 153rd D. B.	Camp Dix, N. J.
Cleeland, R.	Ensign	United States Navy	Care of 5020 Race St., Philadelphia
Coleman, G. K.	2nd Lieutenant	Coast Artillery	Fort Howard, Md.
Cope, T. D.	1st Lieutenant	Science and Research Laboratory, Air Service	Langley Field, Hampton, Va.
Craig, Coulter	Major	Ordnance Officers' Reserve Corps, Supply Division	Office, Chief of Ordnance, Washington, D. C.
Dunlap, V. R.	Lieutenant	Naval Air Station	Pensacola, La.
Evans, E. M.	1st Lieutenant	Motor Transport Corps	Washington, D. C.
Frank, A.	2nd Lieutenant	540th Engineers, Service Battalion	Camp Humphreys, Va.
Gribbel, W. G.	Major	Engineers	Camp Humphreys, Va.
Hathaway, H. K.	Lieut. Colonel	Ordnance, N. A.	American Expeditionary Forces, via New York
Hamilton, R. D.	Captain	Ordnance Dept.	South Amboy, N. J.
Hayden, H. S.	2nd Lieutenant	103rd Engineers	American Expeditionary Forces, via New York
Haydock, C.		Co. 3, Engineer Officers' Training School	Camp Humphreys, Va.
Hollister, C. J.	Captain	Dental Corps, 28th Division	American Expeditionary Forces, via New York
Hoopes, E. M., Jr.	Captain	Utilities Detachment, Quartermasters' Corps, B 105	Camp Meade, Md.
Jamison, R. B.	Sergeant		Camp Hill, Newport News, Va.
Knight, C. O., Jr.	Lieutenant	318th Infantry	American Expeditionary Forces, via New York
Larkin, C. R.		Reclamation Officers' Training Camp	Camp Joseph E. Johnston, Jacksonville, Fla.
Marks, A. A.		Co. "D," 29th Engineers	American Expeditionary Forces, via New York
Mayburry, W. G., Jr.	Lieutenant	11th Brigade, F. A.	Camp Meade, Md.
McCausland, J. R.	Master Engineer		R. T. O. Savenay, Base 701, American Expeditionary Forces, via New York
McCracken, S. L.	Private	Co. "A," 19th Battalion, Inf. Repl. & Tr. Camp	Camp Lee, Va.
Miller, F. W., Jr.	2nd Lieutenant	Ordnance Dept., U. S. A.	Raritan Arsenal, Metuchen, N. J.
Moody, W. M.	Captain	Coast Artillery Reserve Corps	62-S, Fort Monroe, Va.
Myers, W. T.	1st Lieutenant	16th U. S. Cavalry	Mercedes, Texas
Nixdorf, F. S.	2nd Lieutenant	Coast Artillery School	Ft. Monroe, Va.
Otwell, C. W.	Colonel	319th Engineers	American Expeditionary Forces, via New York
Pierce, D. T.	Major	American Red Cross	France
Raynsford, C. O.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
Rodgers, E. M.	Lieutenant	Engineers' Corps	Camp Lee, Petersburg, Va.
Roush, G. A.	Captain	Inspection Division, Ordnance Dept.	517 Shepherd St., N. W., Washington, D. C.
Ruff, A. G.	Ensign	U. S. Navy	U. S. S. "Manchuria," Care of Postmaster, New York City
Sacks, S. I.		Co. "J." 4th Regiment	Camp Parry, Great Lakes, Ill.
Sigmund, P. E.		Engineer Officers' Training Camp	Camp Humphreys, Va.
Spackman, H. S.	Lieut. Colonel	Corps of Engineers, U. S. A.	Hqrs. Cement Mills Companies, American Expeditionary Forces, via New York
Thorpe, A. W.	Master Engineer	Chemical Warfare Service, Co. "A," 2nd Battalion	Edgewood Arsenal, Edgewood, Md.
Watt, W. R.		Co. "H," 1st Regt., Section B, S. A. T. C.	University of Pittsburgh





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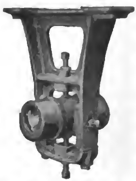

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The Journal extends hearty Christmas greetings
and best wishes for the New Year
to all its readers,
remembering particularly those members of the Club
who, at their Country's call,
have enlisted in the National Service.

Pag.o.c.

THE
JOURNAL
OF THE ENGINEERS' CLUB OF PHILADELPHIA
AND AFFILIATED SOCIETIES

VOL. XXXV-12 DECEMBER, 1918 NO. 169

ELECTRIC WELDING AS APPLIED TO STEEL SHIP CONSTRUCTION *

A series of discussions held under the auspices of the Electric Welding Branch of the Education and Training Section of the U. S. Shipping Board, Emergency Fleet Corporation

Seventh Discussion

ELECTRIC WELDING PRACTICE

By **PROF. COMFORT A. ADAMS**
Chairman of the Electric Welding Committee

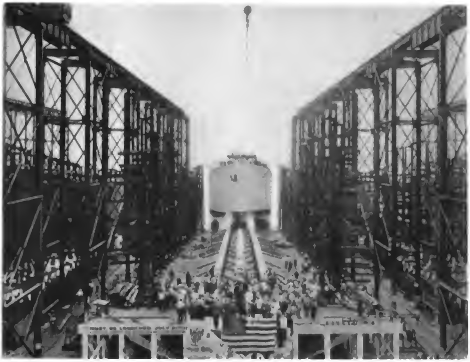
THE history of almost any new industry reveals that the first developments and successes were due to practical men, who, while feeling their way in advance of established theory, obtained results so encouraging as to compel scientific investigations and the establishment of clearly defined governing principles. So particularly has this been true in the case of Electric Welding that the committee which was appointed by the Emergency Fleet Corporation, first to investigate, and later authorized to establish Electric Welding in steel ship construction, has been almost constantly called upon to enlarge its activities, so as to include the ever-increasing new problems in connection with this work which are being encountered in the field.

Although it is recognized in this case that practice has so decidedly preceded theory, nevertheless it may be interesting to trace briefly the developments in this art from the viewpoint of the work done by the Electric Welding Committee, whose personnel is now made up of representatives broadly covering the fields of both Electric and Gas Welding, and whose activities have been carried on largely through its sub-committees, each of which has been assigned to some particular phase or phases of the work—such as Testing, Research, Training, Ship Design, Welding Equipment, the Visiting of Shipyards, Publicity, Report, and Questions of Policy.

TESTING

The methods of testing that have been investigated and considered are Magnetic, Electric, X-ray, and Mechanical.

While the investigations in the Magnetic, Electric, and X-ray lines have not, up to the present time, been carried very far, still there are very great difficulties in making the necessary measurements in such a way as to be conclusive. The Mechanical methods, therefore, appear to be the only ones which yield appreciable promise of any practicable success, and even these are limited in their application. In this latter method the weld is gone over with a hammer or caulking tool, to see whether the welded material can be broken loose or caved in. Such tests are, of course, highly superficial, and are not by any means conclusive. For this reason it looks as if the most important factor in Electric Welding is the skill of the welder, together with such specifications



LAUNCHING OF STANDARD TYPE STEEL SHIP

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* Delivered in the auditorium of the Engineers' Club of Philadelphia, August 7, 1918.

SUMMARY OF TENSILE TESTS
U. S. SHIPPING BOARD, EMERGENCY FLEET CORPORATION

Specimen No.	Weld machined Yes or No	Reduction of area per cent.	Elongation in 8" per cent.	Elongation in 2" per cent.	Yield point lbs. per sq. in. of plate section	Ultimate load lbs. per sq. in. of plate section	Remarks
22	No	54.5	14.75	9.0	39000	66400	Fracture 6.58" from centre line of weld, cracks in weld, cup fracture, dull, silky and fine grained
19	No	56.3	19.75	6.0	37000	65400	Fracture 3.22" from centre line of weld, shear fracture, dull, silky and fine grained
19	Yes	17.8	10.00	12.0	37200	62800	Fracture at weld, air bubbles, dull and non-uniform texture, irregular fracture
22	Yes	12.2	3.75	6.0	37100	50000	Fracture at weld, few air bubbles, dull, non-uniform texture, irregular fracture
15	Yes	8.4	2.00	4.0	.....	39400	Fracture at weld, air bubbles, dull and non-uniform texture, irregular fracture
15	No	...	4.00	8.0	42460	57340	Fracture at weld, dull and non-uniform texture, irregular fracture
3	No	....	12.7	13.0	36300	65470	Fracture at weld, dull, silky and uniform texture; good weld
3	Yes	6.75	3.75	5.0	34300	50600	Fracture at weld, dull, silky, fairly uniform texture, good weld
5	No	....	4.37	7.0	35300	52280	Fracture at weld, non-uniform texture, not thoroughly welded in "V" at weld (fair weld)
5	Yes	7.7	6.75	8.5	35650	61100	Fracture at weld, dull, silky, uniform texture, small per cent., not thoroughly welded (good weld)
23	No	....	3.0	5.0	46440	57060	Fracture at weld, dull, non-uniform texture, not thoroughly welded (poor weld)

governing the manner of doing the work, the materials employed, the kind of electrode and current for each size of electrode, regulations of current, etc., as will insure that the weld is being made under the best possible conditions; and it may be stated, moreover, that under such conditions we have no reason to expect other than good work.

RESEARCH

Too much importance has been attached to the particular characteristics of the machine which supplies the current. The difference between different machines, each with a good operator, is almost negligible as compared with other difficulties which have been largely overlooked in the early history of the art. For example, when a welding job appears to be difficult, frequently the machine has been blamed for this difficulty, while as a matter of fact the trouble lay in an entirely different direction. It is the function of the sub-committee on Research to investigate all such cases, and to segregate the different variables which affect the result of a weld, find out the place of each and the part it plays, and be able to specify conditions under which good welds can be made.

The work that may be expected of good operators working with entirely different systems may be noted in Tables Nos. 1, 2, and 3, which show the result of tests made on ship plates welded in various places. All the welds were made by different people with different systems of current and different electrodes.

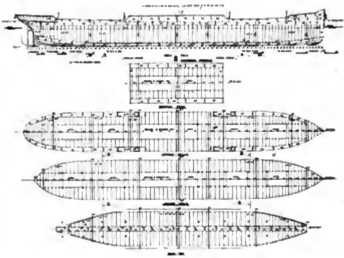
Relative to direct and alternating currents in their effect upon arc welding, the opinion has varied somewhat as to the relative merits of these two methods. One opinion has been that direct current was the only thing, and that alternating current was not satisfactory. One reason for this stand is the difficulty of holding the alternating current arc, the reason for that difficulty being obvious—namely, that if the arc lengthens even a little beyond the safe operating point, it becomes so thin that it goes out between cycles and the current passes through zero. On the other hand this

SUMMARY OF TENSILE TESTS
U. S. SHIPPING BOARD, EMERGENCY FLEET CORPORATION

Specimen No.	Weld machined Yes or No	Reduction of area per cent.	Elongation in 8" per cent.	Elongation in 2" per cent.	Yield point lbs. per sq. in. of plate section	Ultimate load lbs. per sq. in. of plate section	Remarks
23	Yes	3.64	3.5	4.0	37850	51900	Fracture at weld, dull, silky, non-uniform texture, irregular fracture, not thoroughly welded (fair weld)
25	No	....	1.75	4.0	44700	47800	Fracture at weld, dull, silky, non-uniform texture, not thoroughly welded (fair weld)
25	Yes	4.75	2.0	3.5	35300	43700	Fracture at weld, dull, silky, non-uniform texture (good weld)
27	No	...	6.0	7.0	31100	48200	Fracture at weld, dull, silky, "V" shaped fracture fairly uniform texture (fair weld)
27	Yes	2.92	5.75	8.0	30600	45800	Fracture at weld, dull, non-uniform texture, irregular fracture not thoroughly welded (good weld)
16	Yes	13.8	3.75	7.0	38400	50250	Dull, silky, few air bubbles, ragged and not thoroughly welded
16	No	....	5.25	....	40280	58740	"V" shaped fracture, dull, silky, fairly uniform texture, few air pockets (good weld)
18	Yes	10.3	4.5	6.0	37500	54000	Shear fracture, irregular, dull, silky, air pockets, non-uniform texture (good weld)
18	No	....	6.75	11.0	40480	61760	Ragged fracture, dull, silky, air pockets, non-uniform texture (good weld)
20	No	57.6	....	11.0	42200	66480	Fractured 6.18" from centre line of weld, dull, silky and uniform texture
34	....	62.0	....	32.0	55900	58600	Plate material (no weld); dull, silky, uniform texture, cone fracture
33	....	63.5	....	31.0	52200	56800	Plate material (no weld); dull, silky, uniform texture, cone fracture

condition is considered by some to be an advantage, due to the fact that, by reason of the necessity for holding a shorter arc with alternating current, the molten metal from the electrode always drops on that part of the plate which is at welding temperature. An opinion which the writer held at one time with regard to the direct arc was that there was some difference between positive and negative electrodes, which was desirable. It happens, however, that in some cases it is better to make a plate positive, and in other cases to make it negative, so it does not follow that this is an advantage in every case; it depends on the length of the arc, the materials employed, and their electrical as well as their mechanical fusion properties.

With reference to rigid *versus* non-rigid systems of welding, and overhead welds, the sub-committee on Research reported under date of August 7, 1918, as follows:



PLATING PLANS FOR ELECTRIC WELDED SHIP

> The only point was whether the supposed stresses which might be present in case the metals were held rigidly during the welding would cause distortion when the parts were released, and whether a material change would occur with annealing. The conclusion is that if two pieces of metal are allowed to lie loosely and free to move, they will warp and distort in their relative position during the process of welding; yet if they are clamped rigidly, the stresses which are set up are taken up almost entirely by a slight giving in the weld, so that when the parts are released there is no tendency for them to spring out of shape, nor is there any apparent lack of strength which can be regained by supposedly releasing the strains with annealing.
>
> Another matter that we have been investigating, partly by trial and partly by talking with our various welders, is that of overhead arc welding work. The consensus of opinion is that, except for intermittent spots, overhead welds are extremely unreliable. In the first place, it is difficult to deposit the metal at all without great fatigue on the part of the operator; and, in the second place, the quality of the work is markedly inferior, and we have come to the conclusion that it should not be depended upon at all. In other words, overhead welding, in our opinion, is only suitable for temporary tacking.

COLD BEND TEST FOR U. S. SHIPPING BOARD, EMERGENCY FLEET CORPORATION

Specimen No.	Type of weld	Weld machined Yes or No	Angle failure began	Angle of failure	Date tested	Tested by	Remarks
15	V	Yes	....	30°	7/19 18	C. P. H.	Not thoroughly welded. Poor weld. Air pockets, dull, non-uniform texture
19	V	Yes	32°	50°	7/19. 18	C. P. H.	Dull, non-uniform texture, air pockets (poor weld)
22	V	Yes	78°	80°	7/19/18	C. P. H.	Dull, silky, non-uniform texture, not thoroughly welded (fair weld)
16	V	Yes	35½°	76°	7/24 18	C. P. H.	Dull, silky, non-uniform texture, not thoroughly welded (fair weld)
18	V	Yes	65°	86°	7/24/18	......	Dull, non-uniform texture, shear fracture (fair weld)
20	V	Yes	34°	48°	7/24/18	......	Dull, silky, fairly uniform texture, air pockets (fair weld)
24	V	Yes	15°	33°	7/24/18	......	Dull, silky, fairly uniform texture, not thoroughly welded (fair weld)
26	V	Yes	15°	35°	7/24/18	......	Dull, non-uniform texture, not thoroughly welded (poor weld)
32 (P. F.)	V	Yes	....	....	7/24/18	......	O.K. for 180° and when bent almost double (¼") showed small fracture cracks (weld not on pin)
$\frac{24}{2}$	V	Yes	....	....	7/24/18	......	¾" pin, material O.K. at 180°
$\frac{26}{2}$	V	Yes	....	....	7/24/18	......	1½" pin, material O.K. at 180°
$\frac{26}{2}$	V	Yes	....	....	7/24/18	......	¾" pin, material O.K. at 180°, and O.K. when bent double

The above points will by no means cover the work being done by the Research Committee, but will nevertheless give some idea of its activities. It is hardly necessary to say that an enormous amount of work and a large number of men are involved in this undertaking; but that interest is rapidly growing may be known from the fact that the cost of this work is in some instances borne by private corporations, as well as by the Bureau of Standards and the Emergency Fleet Corporation.

TRAINING

The Training Committee, although a sub-division of the Welding Committee, is really in the department of education and training of the Emergency Fleet Corporation. Its function is the training of electric welders and the instruction of electric welders in the art of training others for this work.

ALL-WELDED STEEL BARGE LAUNCHED IN ENGLAND, JULY, 1918

The existence of this committee is, of course, due to the fact that welding activities have greatly outrun the capacity of trained welders to meet the demands placed upon them, and it was early recognized that green men would have to be trained in order to meet the demands.

The schools are located at Schenectady, Newport News, the Submarine Boat Corporation, Hog Island, and at the Ford plant. The time required to make good welders varies, of course, but perhaps an average of from four to six weeks will produce satisfactorily trained operators. In this connection, however, it might be mentioned that one of the difficulties which has had to be met, at the present time, is the rate of wages, since the fixed government rate of 65 cents per hour is not high compared with the wages men employed in other work on vessels are earning.

The improvements in the schools are constantly evident, and so hopeful are some interested in this work of the good to be gained in this direction that predictions have been made that training schools will become an essential part of the employment of skilled labor in all successful industries.

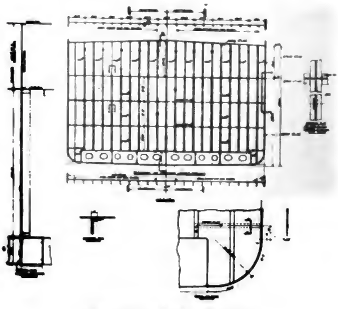
SHIP DESIGN AND COSTS

The sub-committee on Ship Design was appointed originally for the purpose of preparing the design for a completely welded ship, although this committee will, of course, handle any other designing questions that may come up. Its members consist almost entirely of naval architects connected with the main committee, and the accompanying sketches show in small part some of the lines of their activities.

In addition to this welded ship the Design Committee has been interested in the design of the battleship *Target*, which Commander Knox used in illustrating his paper, "The Nomenclature of Electric Welding." The committee is also interested in the preparation of some ship sections at the Federal yard, one of which is a 42-foot section of a 9600-ton ship in which the arrangement of plating is the same as for riveting, although the entire section is held together by electric welding.

In connection with the welded ship above mentioned, figures reduced to a ton basis which have been worked out as to the probable cost of the steel hull may be of interest. This cost has been divided into two parts, namely, welded and other parts, and is considered a conservative estimate of the cost of preparing plates for welding and assembling. The total cost of labor, power, and electrodes, apart from the cost of the steel itself, is $63.50 per ton of steel in the hull. In this welded ship, however, we have only 2300 tons of steel, instead of 2800 tons, which would be used in the ordinary riveted ship. Reduced, therefore, to the same basis of tonnage, this cost is only $52.50 per ton for the purpose of comparison of the riveted ship. The cost of the riveted ship to-day is in the vicinity of $80 per ton, although considerably less than a year ago this riveting cost was in the neighborhood of $65 per ton.

Table No. 4 will give comparisons of the cost of welding on a unit basis. The average speed of welding is five feet per hour, not allowing for the long waits of actual work, and are taken from the English practice. The amount of metal per running foot is 0.6 of a



SHOWING WATERTIGHT BULKHEAD

pound, and the current 150 amperes. The power is estimated to cost 3.6 cents per foot, bare electrodes 7.2 cents, and labor 13 cents. With covered electrodes the cost is much greater, although this difference is due only to the difference in cost between bare and covered electrodes.

Table No. 5 gives a summary of the results obtained in England in gas welding. The figures have been converted by the substitution of American cost for oxy-acetylene labor rather than the English cost. Although American data as to the cost of gas welding is not complete, nevertheless in the practice in this country the difference in favor of arc welding is much greater than indicated in these English figures, particularly when we take into account the reduced cost of bare *versus* covered electrodes. As a rule, however, the gas weld is more ductile than the arc weld. It has been generally considered that the gas weld is more satisfactory for other metals than iron and steel, such as cast iron, for instance.

WELDING DATA ON PROPOSED WELDED SHIP 1/2" PLATE LAP OR DOUBLE V

THE DATA IS BASED ON THE USE OF BARE ELECTRODES AND MOTOR GENERATOR

Average speed of welding on continuous straightaway work	5 ft. per hr.
Amount of metal deposited per running foot	.6 lb.
Curreot 150 amps. @ 20 volts = 3KW	
Motor generator eff. 50 per cent. = 6 KW ÷ 5 = 1.2 KWH per 1 ft. run	
1.2 KWH × 3 cents =	3.6 cts. per ft.
Cost of electrode 10 cents per lb. and allowing for waste eods, etc.	7.2 cts. per ft.
Labor @ 65 cents per hr. ÷ 5 ft. = labor	13.00 cts. per ft.
Total cost of weld per ft.	23.8 cts. per ft.

Data from Capt. Caldwell's letter July 18, 1918, covered electrodes, rheostatic control lioe voltage 100 V., but with .6 lb. electrode per ft.

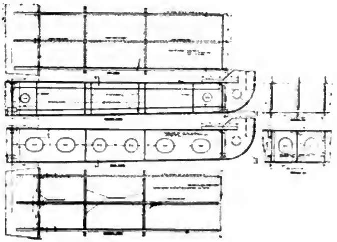
Average speed of welding on contiouous straightaway work	5 ft. per hr.
Amount of metal deposited per running ft.	.6 lbs.
12 KW 5 ft. = 2.4 KWH × 3 cents per ft. run	7.2 cts.
Cost of electrodes	44.16 cts.
Labor @ 65 cents per hr. ÷ 5	13.00 cts.
Total cost ol weld per ft.	64.36 cts.

SHIPYARDS COMMITTEE

The function of this committee is to visit shipyards for the purpose of stimulating interest in the use of electric welding in connection with steel ship construction, and to give such assistance to shipbuilders, or to the men who are doing the welding, as may be possible, since it is of the greatest importance that the managers and superintendents in the yards know of the difficulties of welding, the necessity of skilled welders, and the best possible electrodes for each particular purpose.

It is also the purpose of the committee to bring to the attention of shipbuilders the list of the parts approved by the classification societies, although it might be mentioned that if all the parts approved were welded we should have a program which would tax the industry away beyond its present possibilities. The program for permissible welding as outlined at Hog Island covers a total number of about 225,000 pieces, which it is estimated could be riveted at a cost of about $245,000, and welded for about $99,000, or approximately 60 per cent. of cost of riveting.

This committee, in connection with the Publicity Committee, Equipment and Report committees, is preparing a handbook on Electric Welding in which will be found just such data as everyone who is doing



DETAILS OF BOTTOM SECTION

JULY 18, 1918

REPORT FROM CAPTAIN CALDWELL ON SPEED AND COST OF VARIOUS TYPES OF WELDING

OXY-ACETYLENE

Thickness of plate	Gas per Oxy. c. ft.	Ft. run Acetl. c. ft.	Cost of gas per ft. run	Iron wire for filling in cents	Labor per ft. @ 65 cts. per hr.	Time per foot	Speed in ft. per hour	Total cost per ft. of wald in cents
1/8"	.74	.57	2.25	1.5	5.415 cts.	4m. 55s.	12	9.16
1/4"	3.2	2.4	9.64	1.66	8.66 cts.	8m. 20s.	7.5	19.96
3/8"	7.8	5.5	22.74	4.	13.25 cts.	12m. 15s.	4.9	39.99
1/2"	11.5	8.8	35.02	5.	15.85 cts.	14m. 20s.	4.1	55.87

Oxy. @ 1.4 cents per cu. ft. delivered
Acetylena @ 2.15 cents "
Filling wire 1 cent to 10 cents per foot according to size
Labor @ 65 cents per hour

CARBON ARC
BERNADOS SYSTEM

Plate	KWH @ 3 cts.	Filling metal in cents	Carbon @ 8 cts. per foot	Labor @ 65 cts. per bour	Time per foot of weld	Feet per hour	Total cost per ft. of weld in ceots
1/8"	2.4 cts.	26	16	2.954 cts.	2m. 45s.	22	5.77
1/4"	4.5 cts.	1.	24	5.42 cts.	5m. 2s.	12	11.16
3/8"	9.3 cts.	2.00	40	11.81 cts.	10m. 55s.	5.5	23.57
1/2"	15	4.00	80	18.57 cts.	17m. 0s.	3.5	38.31

Time giveo is total time and includes swaging of weld after welding.
Time during which curreot is approximately 50 per cent. total time of weld

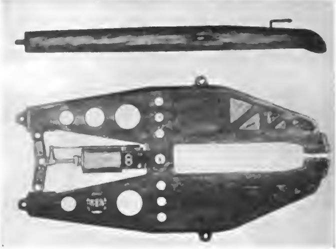
METAL ELECTRODE ARC WELDING

Plate	Power used per foot run amps. at 100 v.	KWH @ 3 cts	Electrode per foot run in ceots	Labor @ 65 cts. per hour	Tima per foot of weld	Speed in feet per hour	Total cost per foot of weld in ceots
1/8"	55 amp.	.54 cts.	7	2.166 cts.	2m.	30	9.71
1/4"	100 amp.	1.35 cts.	12.9	2.954 cts.	2m. 45s.	22	17.2
3/8"	100 amp.	4.8 cts.	19.2	8.66 cts.	8m.	7.5	32.66
1/2"	120 amp.	7.2 cts.	25.5	13 cts.	12m.	5	45.7

American price of covered electrodes approximately 80 per cent. of English price.

The above figures have been obtained from Captain Caldwell's report by substituting American prices for labor and material for the English prices.

electric welding will desire. There will be in this handbook, for example, diagrams of the connections of every type of electric welding apparatus in existence, together with data as to its efficiency under constant load, and under actual ordinary working conditions. At the present time a great deal of misinformation has been brought into the welding field and optimistic statements have been made in the press which have resulted in actual harm, and which it is hoped to neutralize through supplying in this handbook absolutely reliable information.

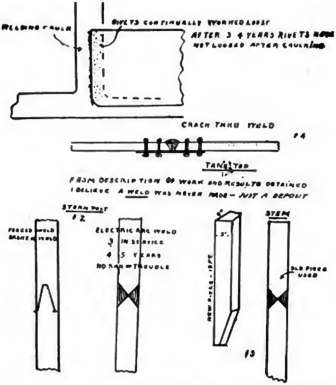


PORTABLE SPOT WELDING MACHINE

CONCLUSION

The spot weld is satisfactory for most purposes. The difficulty in this direction, however, lies in the fact that spot welders are heavy and cumbersome, and have been, up to the present time, difficult to handle in portable form. The power required for spot welding is perhaps double that required for arc welding, but the speed of spot welding and the labor cost is tremendously reduced as compared with arc welding. The large stationary spot welding machines, such as have been used in fabrication shops, will undoubtedly find a tremendous field of usefulness, as in this class of work the limitations have not been found difficult to meet.

With arc welding, on the other hand, the field of usefulness is absolutely unlimited, not only in the shipbuilding field but in all departments of manufacture, and is growing so rapidly to-day that it is very difficult to keep pace with its possibilities.


WELDING CAULK
RIVETS CONTINUALLY WORKED LOOSE
AFTER 3 4 YEARS RIVETS HAVE NOT LOOSED AFTER CAULKING
CRACK THRU WELD
#4
TANK TOP
FROM DESCRIPTION OF WORK AND RESULTS OBTAINED I BELIEVE A WELD WAS NEVER MADE — JUST A DEPOSIT
STERN POST
#2
FORGED WELD
ELECTRIC ARC WELD
3 IN SERVICE
4 5 YEARS
NO SIGN OF TROUBLE
3"
STEM
OLD PIECE USED
#3

WELDED STERN AND STERN PLATE RIVETS ON GREAT LAKES STEAMER

With respect to the all-welded ship, it may be stated that very few people have so far appreciated how good the all-welded ship would be, with the result that the average capitalist is still suspicious of this new method which has not yet been thoroughly proved out. When a man who is paying for ships seeks information in this direction, and is passed along from the ship owners to their superintendents, and from the superintendents to the foremen, and from the foremen to the riveters, it may readily be appreciated that the information on electric welding returned to him has not been very satisfactory.

A further reason why the completely welded ship is not being realized at the present time is the effect of crystallization of the joints under vibration stresses. Most arc welds, although not all, are, relatively speaking, brittle, and ship designers and the classification societies are cautious and afraid of this brittle joint.

As mentioned previously, however, the lists of parts which have been approved by the classification societies for electric welding, together with many other parts which by deduction would be classified as approved, have presented a field for electric welding so large that we are not in any immediate danger of exhausting the present possibilities; and by the time this point is reached, other lists from the classification societies will probably have extended the field in advance of practice, and by these successive steps the field will have broadened, until the completely welded ship is realized.

Eighth Discussion

ELECTRIC WELDING—A NEW INDUSTRY*

By H. A. HORNOR

INTRODUCTION

ABOUT a year ago the Chairman of the Standards Committee of the Institute was requested to investigate and standardize spot welders and the apparatus connected with them. It occurred to the members of this committee that electric welding could perform an important function in increasing the progress of steel ship construction. The work which was started by the Standards Committee was then transferred to the General Engineering Committee of the Council of National Defense. Last winter the Council of National Defence abolished all advisory committees; but at this time the Emergency Fleet Corporation of the U. S. Shipping Board had become so much interested in the subject that they decided to adopt the Committee. The Committee is composed of representatives covering broadly the whole field of welding activities in this country and, although electric welding has been the subject of all the investigations up to the present time, it is now proposed to include gas welding with representatives from all the gas welding associations and companies connected with this industry.

25 KW. 110 VOLT A. C. HAND-OPERATED LIGHT-DUTY SPOT WELDERS

The two main processes of electric welding, namely, arc welding and spot welding, were found by this committee applied in the first case to repairs and in the second case to certain factory quantity production jobs. The work done was in the case of spot welding only on light material, and in neither case very extensive. The processes to be successful in their application to the construction of merchant vessels would have to show reliability in the joining of steel plates from a half-inch to one inch in thickness. To this and kindred problems the committee immediately turned its attention.

The work had all been done in the field where it had been applied by practical men. It was first necessary to formulate the proper nomenclature and symbols. This was thoroughly investigated and a very comprehensive set of symbols has been approved by the committee and is in daily use by those now actively engaged in this new application. The approved nomenclature introduces the subject to the designing and calculating engineer and gives him the instrument by means of which he is able to place his thoughts rapidly and conveniently on drawings.

The manufacturers of apparatus joined the practical man in the study of the problems of electric welding. Apparatus and so-called processes introduced various types of machines suitable for the conversion of electrical supply to the proper values of current and voltage needed at the arc or at the spot. The manufacturer in his eagerness to meet the problem naturally encountered many difficulties. These difficulties increased until a point was reached as referred to above where he demanded some standards upon which his apparatus could clearly be rated. Therefore, the manufacturer was only too pleased to co-operate with the Welding Committee and is today conscientiously aiding in straightening out the difficulties in which he was involved prior to last year.

Arc welding in this country has largely been done in railroad repair shops. It was discovered that the process was much cheaper and could be performed more

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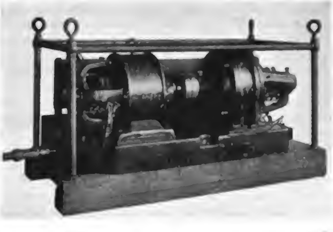
* Presented at a Joint Meeting of the Philadelphia Section of the American Institute of Electrical Engineers, the Association of Iron and Steel Electrical Engineers, the Engineers' Club of Philadelphia and the Electric Welding Committee of the Emergency Fleet Corporation, Philadelphia, Pa., September 16, 1918. Courtesy of the A. I. E. E. Proceedings for September, 1918.



ELECTRIC WELDING EQUIPMENT MADE FOR UNITED STATES GOVERNMENT BY WILSON WELDING & METALS CO.

rapidly than by any of the gas welding methods. It also could be applied without preheating and in many cases without the expense of disassembling complicated pieces of machinery. Spot welding besides being used in many different industries was sought for by the railroad man and there has been built a gondola car which has seen some seven or eight years of service. It is interesting to note here the difference in practice between Great Britain and the United States. The former knowing little or nothing about spot welding had the practice and application of arc welding very well under way; the latter exactly the reverse.

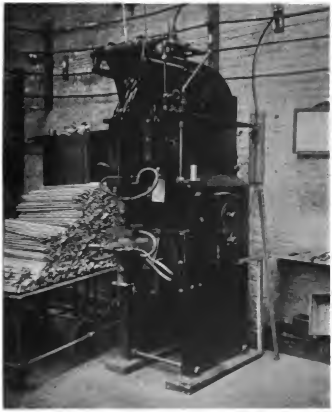
Apparently the attempts to train operators were rather crude and it was early observed that the reliability of the electric weld depended substantially upon the skill of the welder. The manufacturers of apparatus and the superintendents in railway shops had struggled with the problem of training operators, but intensive study had not been given the subject so that there existed in this respect a great deal of groping in the dark.

PRESENT STATUS OF ELECTRIC WELDING

Investigations were immediately undertaken to answer the question whether spot welding could be successfully accomplished using one-inch thick steel plates. An experimental apparatus of large size was erected and put into operation, the results showing that no difficulty was encountered with half-inch and three-quarter inch plates. The same remark applies to one-inch steel plates. In fact, this experimental machine was successful in welding three thicknesses of one-inch plate, a condition which far exceeds the requirements of merchant ship construction. This operation has its historical significance in that this was the first time that any spot welding of this magnitude had been performed. The successful outcome of these experiments has led to the design and construction of large spot welders to be used in the fabrication of ship sections. The practical application of a large five-foot gap spot welder will be made at a demonstration of a forty-foot section of a standard 9600-ton ship to be built at the plant of the Federal Shipbuilding Company, Kearney, New Jersey. This is the largest portable spot welder ever built. It will prove two points in ship construction by the electric method, namely, the clamping of the ship's structural parts for assembly, thereby reducing the time in working the material as well as for the erection of the ship material; and secondly, by the speed of spot welding it will prove the decrease in time for joining the material together. The consensus of opinion is that the large stationary spot welder of five- or six-foot gap will undoubtedly play an important part in increasing the speed of fabricating sections of standard steel vessels. Further investigations are being made and designs are being worked out for special spot welders for use in the construction of bulkheads. The designs proposed are chiefly for shop processes, but it can be asserted that such apparatus will be of undoubted value in the saving of time and man power.

Arc welding had been tried in a great variety of work but there was no conclusive evidence that it could be developed to the stage of joining ship plates with the certainty of full strength. The first stage of this investigational work is now almost completed. Sample welds of half-inch ship structural steel were taken by a

ARC WELDING IN THREE DIFFERENT POSITIONS:—FLAT, VERTICAL AND OVERHEAD special sub-committee to fourteen or fifteen different places where electric welding was being performed. This sub-committee saw the welding done, noted the conditions of current, voltage, electrode, operator, etc., and then prepared the welded samples for tests. The samples were forwarded to the Bureau of Standards in Washington so that the tests should be conducted by parties absolutely disinterested and without knowledge of how the samples were obtained. The results of these tests showed a remarkable similarity, especially when it is realized that they were made by several firms with different electrode materials and under varying conditions of the electrical circuit. Practically all of the welds pulled at over 50,000 pounds per square inch and several over 60,000 pounds, the average being about 58,000. On the bending test one of the samples was bent to an angle of 78 degrees before a crack started and final failure reached 80 degrees. In another case the sample was bent to 65 degrees before the crack started and final failure did not occur until 86 degrees. The point of importance here is that all the welds showed a reliability and satisfactoriness which makes conclusive the opinion that electric arc welding is applicable for the joining of steel where the structure is submitted to live loads, bending strains, static pressure or the like. The sub-committee on Research is pursuing this subject and practical samples are being prepared for similar tests using three-quarter and one-inch stock material. The results of these tests will be available as soon as the reports are presented and approved by the Welding Committee. The Research Committee is also preparing various types of joints in heavy plating. These will be submitted to all the regulation tests and in addition to shock and fatigue tests and tests to destruction.

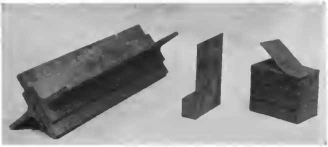


30 KW—440 VOLT A. C. SEMI-AUTOMATIC SPOT WELDER. HYDRAULIC PRESSURE; CAPACITY, TWO ½" PLATES

SAMPLE SHOWING INDIFFERENT AND GOOD BUILT-UP WELDS

To give a further indication of the large size practical tests which are being carried on at the present time it may be stated that three 12-foot cube electrically welded tanks are now being constructed. These tanks are built in such a way that from twelve to fifteen different designs of joints are used in their construction. After these tanks are built they will be subjected to a static strain and the deflection of the seams will be directly measured. Afterwards they will be tested by external shock and crushed to destruction. Portions of the joints will be cut, sent to the Bureau of Standards, and again tested for the sake of accumulating precise data. In this connection there is being built at the Norfolk Navy Yard a battle-towing target. The keel of the target, 110 feet long, will be entirely electrically welded and the results of this practical demonstration will be carefully recorded after it has been put in regular service.

It is to be expected that the manufacturers of apparatus, being keenly observant of the increased interest in electric welding as well as in the future, which is probably now unquestioned, would be active in their desire not only to improve their present facilities and their design of apparatus but also to proceed themselves to follow the trend of the investigations made by the Welding Committee. The consequence of this has been a large increase in output of apparatus and it may be unhesitatingly stated that there are no difficulties in the way of obtaining all the electrical welding apparatus that is needed. One interesting point is that certain manufacturers who were decidedly of the opinion that direct current was the only proper current to use for arc welding have within a very recent period changed their point of view and are willing to admit that alternating current may have certain advantages in the development of this art.



SAMPLES OF WORK DONE ON 30 KW SPOT WELDER
A—$\frac{5}{16}$'' structural members welded to $\frac{3}{16}$'' plate
B—1'' bar welded to No. 16 gauge plate
C—39 pieces of No. 16 gauge plate

The electric arc requires a reduced voltage and this is difficult to attain with direct current without relatively expensive machines or a useless expenditure of energy. The practice in this country in manufacturing establishments of any size has been toward an increase in the supply voltage so that very few large manufacturing plants use less than 220 volts direct current. With this voltage the only economical method of transformation is in the use of a motor-generator set. The efficiency in this case is in the neighborhood of 50 to 60 per cent. It is possible to use a supply voltage of 110 volts with a variable resistance which cuts down the voltage to the arc volts. This gives a very poor efficiency. In the case of alternating current the supply voltage can be reduced by a transformer which will supply, as in the case of direct current, a sufficient voltage for striking the arc and a satisfactory reduction when the arc has been struck. On the other hand, if a low voltage alternating current is provided a simple reactance may be introduced which has some of the same wasteful characteristics of the resistance used with the direct current. The average apparatus will permit of electric arc welding consuming about six to eight kilowatts per welder, but if low voltage is provided there are certain outfits which will reduce the consumption as low as three and one-half kilowatts per welder, or even less.

Without entering into an elaborate analysis of the relative costs of electric welding, it may be broadly stated that there is hardly any question that the electric process is cheaper than any other. The same may be said as regards speed and also reduction of man power. In a recent discussion of this subject President Adams stated that at one of the Eastern shipyards the total number of parts on the welding program of the standard riveted ships now building at that yard amounted to 225,000. The labor cost for riveting these pieces is about $245,000 and for welding about $99,000, making a saving of $146,000. But this is only a drop in the bucket when compared to what might be profitably done in this line. He stated further that in certain particular instances the saving is as great as 90 per cent.

One of the interesting questions discussed with some fervor by the members of the Welding Committee is the advantages of the bare and covered electrode. Regarding this discussion no definite facts can be stated. In England the practice has been to use the covered electrode which protects the welding arc from contact with the air, thus guarding against too great a formation of oxide. The practice in the United States up to the present time has been largely bare wire. Recently, American investigators have discovered the important fact that there are advantages in the covered electrode and many experiments are now being made, some with results. It is important to observe that in the above-mentioned tests of welds, the best one of these samples was made with a coated (not an asbestos covered) electrode using alternating current. The point in this case seems to rest upon the question of the ductility of the weld and it would seem that the bare electrode does not make as ductile a weld or at least one as easily bent as the coated or covered electrode. The question of the ductility of the weld is one of much importance in the application to ship construction and will doubtless be of importance in other allied industries. It is, therefore, a question of serious importance and constitutes an important part of the work of the sub-committee on Research.

No matter what the type of electrode is nor its composition, no matter what kind of shank material is to be welded, no matter what kind of apparatus is employed, the reliability of the weld rests mainly upon the man who makes it. This man, if he has been properly trained and is skilled in the art, knows instantly whether he is making a weld or not. He becomes after much practice able to judge fairly well upon looking on a finished weld whether it is a good weld or not. The work of training electric welding operators early became a part of the functions of the Education and

ARC WELDING BOILER FLUES

Training Section of the Emergency Fleet Corporation. The men connected with this work are members of the Welding Committee. Schools for the training of operators as well as for the conversion of operators into instructors, are established in many parts of the country. The objects held in view by the training department are first to give the man intensive practice work so that he becomes a good craftsman. The methods are simple to start with, as the exercise of the right arm muscles must become flexible enough to permit the operator to give the required movement to the electrode. By a graduated series of exercises this is accomplished in about eight weeks. The man is allowed to do production jobs in the shop which gives him confidence through responsibility. It becomes desirable at this time to give the man some outside work on ships and where this is practicable it is done. The man is then turned over to an instructor, who gives him an intensive course in pedagogics lasting from five to six weeks. At first sight it would not seem necessary to so instruct a man, but it is not generally understood that teaching after all is itself a trade. The experience with the men in this respect is most interesting. In nearly every case the man has resented this course at the start, but at the end has turned completely around and in many cases has desired an even more extensive training. What is really accomplished is to give the man the necessary confidence to impart the knowledge that he has gained to another green man. The men under training are taken from the various industries, especially the shipbuilding industry, and after they have finished their instructor training course are returned to their employer to carry on the instruction, in their own plant. The men who go through this training as provided by the Emergency Fleet Corporation are certificated when they have shown themselves to be entirely proficient. It is not possible nor expedient for the Emergency Fleet Corporation to require the certification of all electric welders. It is the consensus of opinion that all industries doing serious work with the electric arc should use men who are certified as to their ability in the art of electric welding. The main reason for this opinion is that the operator must be a conscientious workman or the weld will not be of perfect quality.

ARC WELDING AROUND RIVET HEAD TO PREVENT LEAKAGE

PARTIALLY COMPLETED ARC WELDED SEAM—NOTICE TACK WELDS TO HOLD PLATES TOGETHER

This brings forward another problem upon which a great deal of experimental work has been and probably will continue to be done, namely, a practical and scientific method of testing a welded joint after it has been made. There have been a number of suggestions made for the solution of this problem. They are, briefly, as follows:

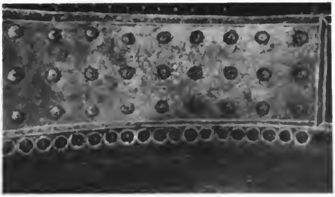
(a) Mechanical. By hammering the weld or by chipping at frequent intervals.

(b) Electric. By means of resistance or voltage drop.

(c) Magnetic. By means of the permeometer or the change of conditions of the magnetic circuit.

(d) X-ray. By means of an exposure on an X-ray plate.

At the present time none of these suggested methods have been productive of conclusive results and recourse must be had to the purely mechanical methods of striking heavy blows on, or adjacent to, the weld or by using a chipping hammer and making intermittent examinations. It would seem by far the best procedure to make the inspector proficient in the art so that he may closely observe the welders while at work.



PATCH IN FIRE BOX

This may be accomplished by a two or three weeks attendance of inspectors at any one of the electric welding training centres.

METHODS OF ELECTRIC WELDING

There are many methods and processes of electric welding, but the two main ones that interest the committee at the present time and alone have been mentioned so far are the spot welding and arc welding. It may be a surprise to some of the oldtime welders to consider electric welding as a new industry. In substantiation of this statement it may be well to describe briefly what is meant by electric welding as it is practiced today.

Spot welding is not much different in the methods of procedure or in design of apparatus as when it was first introduced. Copper electrodes, water-cooled in the heaviest machines, are placed on opposite sides of the material to be welded together. The joint is a lap joint. Machines are now so designed that two spot welds may be made at one time. The routine of the operation is as follows:

> The electrodes are brought into contact with the materials to be joined, current is supplied sufficient to give the required heat, pressure is then applied, the current is removed, and the pressure is removed; the weld is then complete.

The operator has a perfect indication of making a good spot weld by the use of a button placed under the electrode, observing which he knows exactly the proper timing of the operation. There is therefore no question as to a good, bad, indifferent spot weld. Automatic spot welders have been designed and built, but it is the general opinion that they add complication to a process which in itself is very simple.

The process of arc welding is as follows:

> One side of the electric circuit is connected to the material to be welded, the shank material is usually prepared by beveling the edge of the pieces to be welded together. The other side of the electric circuit is connected to the electrode. The operator is provided with a holder which carries the electrode. By touching the electrode to the shank material the arc is drawn. The skilled operator now moves the electrode from side to side of the groove, giving a semi-circular motion, while at the same time moving the electrode along the groove.

It is important that the arc "bite" into the shank metal, creating a perfect fusion along the edges, and the movement of the electrode is necessary for the removal of any mechanical impurities that may be deposited. In the coated electrode it is further necessary that the slag which forms for the protection of the pure metal be worked up to the surface, and it is extremely important in the event of a second or third layer that the slag or impurities be carefully scraped away before the virgin metal is again laid on.

The operator in arc welding is protected with either a hand screen covering his face with special glass through which to observe his work. The electric arc emits dangerous invisible rays in both the upper and lower spectrum scale and it is quite evident that both the infra-red and ultra-violet are dangerous in their effect; the former is pathological, the latter actinic. The operator further uses gloves for his hands and for the very difficult work of overhead welding it is necessary for him to use a helmet which partly covers his breast.

DEVELOPMENTS

The tendency of developments in spot welding has already been slightly touched upon. In their nature as applicable to shipbuilding the advancement will naturally have to proceed toward means for accomplishing spot welding in very cramped locations. This makes an exceedingly difficult problem, as the power requirements are such as to preclude any very small device. In riveting one half of the apparatus is on one side of the work and the other half on the opposite side and it is difficult to conceive of any method of spot welding that will admit of such an arrangement. In shipbuilding it is quite probable that designs may be made that will permit of a large or at least increased amount of spot welding in the actual construction of the vessel. Certainly, present designs of riveted ships will not allow of this to any great extent.

ELECTRICALLY WELDED MOTOR LAUNCH BUILT IN 1915 AT ASHTABULA HARBOR, OHIO

As already stated, spot welding can now take its place in the fabricating shops and it is to be expected that within a few months spot welding will begin to supplant riveting in this field. The only drawback to this will be the sufficient production of spot welding apparatus.

The tendency of development in arc welding is toward the automatic machine to obviate the responsibility that has to be placed upon the skilled operator. Intensive work has been done within the last few months in the line of automatic arc welding machines and at the present time sample tests of welds made by such apparatus have been sent to the Bureau of Standards. These machines will occupy a very important position in repetition work. They will not immediately supersede the skilled operator in repair work, or in special jobs, but it may be expected that the development of such machines will bring about apparatus which can be man-handled and will eventually take the place of most of the hand work as it is now known.

THE ELECTRIC ARC

Of the scientific advancement in the art of electric welding there is so much to be treated that only a general outline can be considered at this time. The research work has only just begun. Practice has preceded the scientific investigation. The field, therefore, is full of most interesting problems. Those who have been following the development of the past six months are deeply interested to know the fundamental reasons. The investigational questions may be grouped into three main divisions:

1. Metallurgical.
2. Physical.
3. Electrical.

The metallurgist has yet to tell us what the conditions of the metals are after the electrode material has fused with the parent metal, and to determine what the proper conditions must be to produce a good weld. This problem has in it a great many variables. The physicist must explain the atomic or electrode conditions which permit of the combinations at the high temperatures involved and must explain the phenomenon of overhead welding. The electrical investigator must determine all the various phenomena connected with the preferences between and the advantages of the use of different forms of electrical energy and the varying characteristics of the electric circuit in producing different types of welds.

CONCLUSION

From the preceding remarks it must be conceded that the Welding Committee of the Emergency Fleet Corporation has already crystallized the problems connected with this art. The working functions of this Committee have been laid down upon the broadest possible lines. Liberal opportunity has been given every one to state in detail his opinion and to express the reasons for his preference on every point connected with this subject. The Committee goes even further than this. It furnishes those interested with every new idea that is brought to bear upon the subject after sifting from the suggestions any question of doubt or misstatement of fact. All suggestions of improvement or problems of special application are gladly taken in hand, thoroughly investigated, and reports made. It will welcome any comments that those connected with the industries may desire to lay before it. The personnel is at the present time such that it can devote not one but many minds to the solution of any specific problem that is laid before it.

The Committee early discovered that the literature of electric welding was very much clouded by misstatement of fact or half-baked theory and much of the time of the Committee has been taken up in disproving such statements. In order to spread the results of this work to all quarters a handbook is now being prepared which will contain only definite facts and results of investigations as are approved by the whole Committee. This handbook will be made available to all those who desire to acquaint themselves with the proper means of accomplishing good and reliable electric welding.

Complete and detailed notes on all discussions may be referred to at the Electric Welding Branch, at 253 North Broad Street, Philadelphia, Pa.

THE METALLURGY OF ELECTRIC FURNACE STEEL PROCESSES *

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INTRODUCTION

THE successful application of electrically heated furnaces to the manufacture of steel is an important advance in the commercial production of all high-grade steels.

In all preceding iron and steel processes distinct metallurgical features dominate which directly influence the nature of the product and limit the process to products of one general nature. These features are oxidation, reduction and acid or basic conditions; the two former being by far the most significant. The general effect of basic or acid influences is really largely dependent upon the oxidation or reduction features, as the metals entering into steel manufacture exhibit acid or basic properties usually only when oxidized.

HISTORY

The ancient processes, dating back to 3500 B.C., were a combination of first reduction and then oxidation, the product being the oxidized iron from the earlier stages of the process. During the Fourteenth century the first pig iron from which modern blast furnaces developed was made. The operation was the first step or reducing operation of the preceding processes. After this the combination of reduction and oxidation of the ancients was broken up into two distinct operations: first, the reduction of iron from the ore; second, the oxidation of the carbon and chemical impurities from the product of the first.

The first real tonnage operation was introduced in 1784, when the present-day puddling process was developed. This is entirely oxidation. The first liquid steel process was invented in 1740 and is our present-day crucible method. This removed the mechanical impurities from the product of the previous oxidation processes and placed the molten material under reducing conditions.

Since the introduction of the crucible process steel-making has developed upon definite metallurgical principles.

In 1856 the Bessemer Converter was developed. The predominating feature is oxidation of elements by means of an air blast passing through molten iron. This process is dependent upon the oxidation principles.

The other great steel process is the Open Hearth, which was invented in 1864, by which cold materials are melted and the desired elements oxidized and removed. The Open Hearth process is oxidizing, but to a less extent than the Bessemer.

METALLURGICAL CHEMISTRY OF STEEL MANUFACTURE

The reason why the two great steel-making processes are oxidizing is that the high temperature which must be obtained for proper fluidity can be secured only by *complete* combustion of the fuel employed. *Complete* combustion necessitates an *excess* of oxygen, the excess being readily available for the oxidation of other elements which will unite with it.—Oxygen, which is a necessity for the removal of elements from pig iron, is available in fixed quantities from sources other than the air, but a process depending upon complete combustion of fuels (in intimate contact with materials employed) for its temperature is necessarily subjected to oxidation until its completion, and hence is an oxidation process.

The development of electrically heated furnaces gives to the steel manufacturer a container in which the fuel for the necessary temperatures is neither oxidizing nor reducing, and the temperature obtainable can be far in excess of steel-making requirements.

The metallurgical importance of the electric furnace to the steel industry is based upon this one feature—a neutral fuel having no chemical function, which makes possible the production, at will, of oxidizing reducing conditions.

The second important principle of steel metallurgy which must be understood in order to comprehend the possible flexibility of electric furnace processes is the relation between the basic and acid properties of the various elements entering into steel manufacture. The elements are classified below according to basic or acid properties and the chemical form in which their properties are effective:

Basic elements	Basic form	Acid elements	Acid anhydride
Fe (Iron)......	FeO Fe_2O_3 Fe_3O_4	Si (Silicon)....	SiO_2
Mn (Manganese	MnO	Al (Aluminum)	Al_2O_3
Ca (Calcium)..	CaO (Lime)	P (Phosphorus)	P_2O_5
Mg (Magnesium	MgO	S (Sulphur)...	S, SO_2
Ni (Nickel)....	NiO_2*	W (Tungsten)	WO_3
		V (Vanadium)	V_2O_3 V_2O_4 V_2O_5

* Very weak base.

In addition to acid and basic properties, there are elements which, at the temperature of metallurgical chemistry, are neither basic nor acid, but which may become oxidized, and as elements or oxides influence metallurgical processes. The principal elements in this class are:

C (Carbon) oxidizes to $COCO_2$.
Cr (Chromium) oxidizes to Cr_2O_3.

The significance of bases and acids is that the oxides of the basic elements combine only with acid anhydrides. At steel-making temperatures true acids are not in existence, so that hereafter, in using the word acid, I shall mean the acid anhydride. Both basic and acid elements are of different degrees of affinity for oxygen and the oxides and acids for each other, and these degrees for the same elements sometimes vary with their temperatures. It therefore follows that for the removal of an acid element from the steel the anhydride of that element must be produced, and a suitable basic element, usually oxidized, must be introduced to combine with it in such a permanent form that it will not under normal conditions return to the steel. For the removal of a basic element, the reverse must be resorted to, *i.e.*, the element must be oxidized to its basic form, and a suitable acid introduced to combine with it in a permanent form.

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* Presented before the Philadelphia Section of the Association of Iron and Steel Electrical Engineers, October 9, 1918, at the Engineers' Club.

These general principles apply to all iron and steel processes from the ancient forges to the present-day electric furnaces; the feature of these principles which predominates in any one process marks the characteristics of the product of that process.

For the first time in the history of iron and steel a process where oxidation or reduction may be produced when desired during the process, and in the sequence necessary, has been developed by the use of the neutral fuel of the Electric Furnaces. This adapts the Electric Furnace to the metallurgical accomplishments of any one or all of the previous existent liquid-steel processes. It would not be possible in a paper of this nature to give the detailed metallurgical features of the various processes. Our immediate interest centres in a comparison between the commercial Open Hearth process, the high-grade product of the Crucible process, and the possibilities of the Electric Furnace process. A discussion of these will be sufficient.

All iron and steel products contain the following elements:

Element	Pig Iron		Steel	
	Low	High	Low	High
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Carbon	2.50	4.50	0.02	1.50
Manganese	0.30	4.00	0.02	1.50
Phosphorus	0.04	2.00	0.01	0.10
Sulphur	0.02	0.20	0.02	0.10
Silicon	0.50	3.50	0.01	0.50

Carbon and manganese are desired in exact but varying percentages in order to impart desired physical properties. Phosphorus and sulphur are impurities, and their elimination is desired as completely as possible. Silicon is considered a deoxidizer and is usually desired in small percentages, about 0.15 per cent. to 0.25 per cent. to insure the steel being free from gas pockets, known as blowholes, after it solidifies. Another impurity in steel, about which we theorize a lot and have little direct knowledge, is iron oxide. Iron oxide in the form of FeO is supposed to exist in steel as mechanical particles held in suspension, and as oxide dissolved in the metal. It renders the steel "red short" or brittle when hot, and tends to involve gas in the cast steel during solidification, the gas in turn producing internal defects known as blowholes.

In the manufacture of a heat of steel it is therefore necessary to be able to add to or reduce the carbon and manganese contents at will, to reduce the phosphorus and sulphur and control the silicon. In addition, any alloys for the production of special grades of steel must be added without excessive loss through oxidation. For the highest grades of steel, oxides must be reduced to a minimum.

With this brief outline of principles and requirements, the means of securing the desired results in the three processes will be taken up separately.

CRUCIBLE PROCESS

In the Crucible process small crucibles holding from eighty to one hundred pounds of metal each are placed in a furnace of the regenerative type. Any number of crucibles up to probably sixty are placed in a furnace at a time. The crucibles are covered and the material is melted. After melting and "killing," the crucibles are drawn from the furnace by hand, and poured into a ladle or cast direct from the crucible into the ingots.

Crucibles are made from graphite and clay, and are therefore acid in character, due to the clay, and reducing because of the graphite. The air and flame being kept from the contents of the crucible, the atmosphere is at all times reducing. It is therefore evident that a control of the carbon during the operation is not possible. The average carbon content of the materials charged will be the content of the product, except that the melted steel will absorb a few hundredths of a per cent. from the graphite of the crucible. Phosphorus, which must be oxidized in order to combine with a basic oxide, has no available oxygen, nor has it any basic oxide with which to combine. The introduction of a basic oxide would result in a combination of that oxide with the acid material of the crucible and the consequent fluxing of the crucible. The acid material of the crucible has a greater affinity for a base than the acid form of phosphorus; hence the impossibility of the removal of phosphorus.

Manganese could be reduced from steel in either basic or acid surroundings by being oxidized and going into the slag. In the crucible, however, where oxygen is not available, the manganese of the charge will appear in the finished product.

Sulphur is likewise not controllable. It appears that, in the presence of a great excess of manganese, manganese and sulphur will combine to form the nonmetallic compound MnS; however, in the crucible process the required percentage of manganese is not available.

Silicon under reducing influence cannot be oxidized to form its acid anhydride, and therefore is not removed under normal conditions in the crucible process.

This reducing condition, however, permits the introduction of such easily-oxidized elements as tungsten, molybdenum, vanadium, etc., without excessive loss.

It further places the metal at all times under conditions which will dissociate any contained iron oxide. The oxygen of the iron oxide combining with the carbon of the crucible goes off as gas, leaving the iron behind; or it combines with one or more of the easily oxidized acid elements, such as silicon, vanadium, etc., and passes into slag.

It is therefore evident that the crucible process is a remelting process in which the analysis of the product will depend upon the analyses of the materials charged, and the only metallurgical feature of a purification nature is the possible reduction of contained oxides and the removal of mechanical impurities after melting by reason of their great difference in specific gravity.

The fact remains, however, that the product of the crucible process has maintained for one hundred and seventy-five years its enviable record of quality which has been challenged only by the recent product of the carefully operated electric furnace.

OPEN HEARTH

The Open Hearth process is divided into two kinds, the acid and the basic. The furnaces, which are regenerative, are the same in construction, but the materials from which the bottoms or hearths are constructed are either acid or basic, depending on which process is desired. In the acid open hearth, the bottom is made from sand, which is practically pure SiO_2, while the basic hearth is made from calcined dolomite (CaO,Mgo) or mangesite (MgO), these materials being strongly basic. The slag in the acid and basic processes must be acid or basic respectively, for a basic slag in an acid furnace will tend to become neutral, and will combine with the bottom materials, and the reverse in the basic furnace.

Open hearth processes depend on combustion of pulverized coal, liquid fuel, or gas, in the hearth of the furnace, for their temperature, and are therefore always subjected to oxidizing conditions. The melting point of steel rises as its carbon content decreases, and, as the carbon introduced into the open hearth charge is necessarily oxidized from the start of the process, an excess of carbon must be charged to permit finishing within the limits desired, and to secure fluidity during the refining operations without necessity for maintaining the furnace at maximum temperature. The excess carbon has also the function of preventing an overoxidation of iron during the melting operations by combining with the oxygen of the air.

It is customary to secure this carbon by charging pig iron and scrap. In the basic furnace it is necessary to average at least 50 per cent. pig iron in the charge, while in the acid process 25 per cent. iron is usually sufficient.

We will limit our discussion to the basic process, as it is more nearly comparable to that of the Electric Furnace. The Acid Open Hearth does not permit the elimination of phosphorus and sulphur, which is the main point of variation in the two processes. The difference in quality of the products is much discussed, but not yet fully determined. The following example of a normal basic open hearth heat will be assumed to illustrate the principles of oxidation and reduction and the methods of eliminating impurities:

The charge consists of 50 per cent. pig iron and 50 per cent. scrap, analyzing as follows:

	Pig iron	Scrap	Average composition
	Per cent.	*Per cent.*	*Per cent.*
Carbon	4.00	0.50	2.25
Manganese	1.00	0.60	0.80
Phosphorus	0.25	0.02	0.135
Sulphur	0.04	0.04	0.04
Silicon	1.50	0.15	0.825

The first consideration is the silicon; we have 0.825 per cent. of the charged weight of this element which will be rapidly oxidized to SiO_2, a strong acid anhydride. In the form of SiO_2, it will amount to 1.765 per cent. of the charged weight. In order to prevent its combining with the basic materials of the bottom, basic material, lime (CaO) or its equivalent in limestone, is added, so that the resulting slag will have an excess of CaO. These slags should not run over 20 per cent. SiO_2, and preferably less. If we figure on 20 per cent. SiO_2 in the slag, and the lime available contains 5 per cent SiO_2, it will require, to provide for the 1.765 per cent. SiO_2, 9.4 per cent. of the charged weight of pig iron and scrap in lime. The finished open hearth slag will average 50 per cent. CaO, so that the slag volume resulting from 9.4 per cent. lime will be close to 18.8 per cent. of the weight of the charge.

During the period that the charge is melting, when the pig iron and scrap come in direct contact with the burning gases and air, iron, carbon, manganese, phosphorus and silicon are oxidized. Iron oxide in the form probably of FeO melts and increases the fluidity of the slag which is forming from the lime and silica; manganese likewise forms MnO, which passes to the slag. Phosphorus, oxidized to P_2O_5 and being acid, combines with the lime of the slag, forming calcium phosphate. At the end of the melting stage the charge will analyze approximately as follows:

Carbon	1.00 per cent.
Manganese	0.25 per cent.
Phosphorus	0.03 per cent.
Sulphur	0.04 per cent.
Silicon	0.10 per cent.

The slag will analyze:

SiO_2	20.0 per cent.
FeO	15.0 per cent.
MnO	3.6 per cent.
R_2O_5	2.8 per cent.
CaO, MgO	58.0 per cent.

The metal is now entirely covered by the slag and no longer comes in direct contact with the air and gases. It is, however, blanketed by a slag containing FeO. The carbon of the steel will combine with the oxygen of the iron oxide in the slag and will pass off as gas. The gas produces an ebullition or boiling, which brings the metal again in contact with air, and replenishes the supply of iron oxide in the slag, which in turn passes oxygen on to the carbon in the steel beneath it. It further happens that manganese will combine with oxygen in preference to carbon or iron, and the manganese in the steel bath will therefore be changed to MnO and pass into the slag. Phosphorus is likewise oxidized, and, combining with the lime, is retained in the slag.

To hurry the process and make the oxidation of phosphorus more complete, and the elimination of carbon more rapid, iron oxide in the form of iron ore is added. This brings oxygen into more intimate contact with the steel, and the gas which is generated brings the steel and slag into greater contact.

When the desired carbon is reached and the temperature is right, the recarbonizing and deoxidizing period begins. Assuming that our theories are correct, the steel, as soon as molten, absorbs iron oxide, which must be partially eliminated to insure good rolling qualities and steel free from inclusions of slag-like particles and gas pockets called "blowholes."

This deoxidation is accomplished by adding elements which have a greater affinity for *oxygen* than iron, such as silicon, manganese, and aluminum. A certain percentage of manganese is almost invariably specified in finished steel, depending upon the grade. It will, however, in all grades average probably 0.50 per cent. Silicon in all grades will average between 0.15 and 0.20 per cent.

Manganese is always added in the form of ferromanganese, but the method of making the addition varies in different plants; one of the following, however, is usually employed:

1. Part in the furnace before tapping and part in the ladle while tapping.
2. All added in the ladle while tapping.
3. All added in the furnace just before tapping.
4. Added in the form of molten manganiferous pig iron containing 5 per cent. to 7 per cent. manganese. This addition is made in the ladle while tapping.

The manganese may be cold, and broken into small lumps, or it may be molten.

Silicon, in the form of ferro-silicon, is almost invariably added in the ladle.

Aluminum, if used at all, is added in the ladle or in very small particles, while the steel is being teemed into molds. For the highest grade steels aluminum is considered by many as an injurious element and its use is very much restricted, although its deoxidizing power is over fifty times that of manganese.

The deoxidizing period of the basic open hearth process, therefore, begins within a few minutes before tapping, or during tapping into the ladle. This is necessarily so because of the continuous oxidizing influence of the furnace, and the basic oxidizing condition of the slag. This oxidizing is not only incomplete but the oxides of the deoxidizing elements are held in suspension in the steel and are frequently found in the finished steel product, not having had sufficient time to separate from the molten steel after forming.

ELECTRIC FURNACE

The Electric Furnace process is divided into two distinct parts:

1. The oxidizing period.
2. The reducing period.

OXIDATION PERIOD

The function of the oxidizing period is to secure exactly the results obtained by the open hearth process up to the time of recarburizing. The operations vary from those of the open hearth in two ways:

A. Oxidation must be secured almost entirely from ore, or rust on the materials charged. As mentioned before, oxygen is not available from the fuel, and must therefore be added in some other form. If materials free from oxides are charged into an electric furnace and melted, the reduction of carbon, manganese, phosphorus, and other elements requiring oxygen for their removal will be but slight.

B. The other distinct variation is in the required charge. Pig iron is not a necessity, because any desired temperature may be reached, and oxidation is but slight. This permits of a charge of 100 per cent. scrap if desired, and, because of a low content of silicon, a comparatively small slag volume.

With these two exceptions, the operation of the first period is identical with that of the open hearth. When the desired removal of oxidized elements has been obtained, the highly oxidized slag which is holding these elements is scraped out of the furnace, leaving the metal bare. This ends the first period of the process.

REDUCING PERIOD

As soon as the first oxidized slag is removed, materials are charged into the furnace for producing a second slag. The chief functions of this second slag are, directly, for the removal of sulphur, and indirectly to blanket the steel and protect it from absorbing carbon from the carbonaceous material used to secure the reducing atmosphere. This slag should be as basic as possible and still be of the right degree of fluidity. Such a slag is made up of a mixture of lime, fluorspar, and sand in proportions which will produce a mixture of 25 per cent. silicon and 65 per cent. to 70 per cent. lime, the balance being such impurities of the materials as manganese, aluminum, etc.

As soon as this slag is melted, carbonaceous materials such as coke, anthracite or bituminous coal, or some form of carbon, is scattered over the surface. In the period during which the slag is melting, a certain amount of oxidation takes place due to the air leaks in the furnace, and the slag is colored black or brown by these oxides. When the carbon is added, however, the oxidation is ended, for what oxygen enters the furnace will combine with carbon in preference to iron or manganese. The same holds true of oxides which may be present in the slag. Iron, manganese, phosphorus, tungsten, chromium, and vanadium oxides, if they are present in the slag at this stage, will be reduced to their metallic state, and in this condition, being unable to act as either bases or acids, will return to the steel. Iron or manganese oxides existing in the steel in suspension or solution will rise to the surface and undergo the same reduction process, their oxygen going off as a gas and the metal returning to the bath. This reducing action is so strong that silicon, which is probably the strongest acid element commonly employed, may be added through a strongly basic slag without loss of any appreciable percentage of the addition. If the temperature of the slag is sufficiently high, the silica, which was added as sand, will be partially reduced, probably directly under the arc, and silicon will enter the steel. I have been told that analyses directly under the slag have shown metal containing as high as 2.00 per cent. silicon in steel to which no metallic silicon was added. At the temperatures attained under these conditions some CaO or lime is dissociated, and CaC_2 is formed. This is evidenced by the strong odor of acetylene produced by placing this slag in water.

Sulphur is removed from steel by this strongly basic slag at high temperature probably in the form of Calcin Sulphide (CaS). This reaction increases with temperature and makes it possible to reduce sulphur to a minimum, a feature which is not possible by any other steel process.

The progress of this reducing period is readily observed by the appearance of samples of the slag when cooled. Oxides, other than silica and lime, color the slag, a very small percentage being sufficient to make it black, brown or green. As the reduction proceeds, the slag changes from black to brown, and if chromium is present, to green, and finally to white, when free from oxides. When white it no longer has the bonding power of the oxides to hold it together when cooled, and quickly crumbles to a powder in the air.

When this condition is secured, the final additions of alloys are made, without loss of any, and when the temperature is correct the steel is tapped and poured.

The four samples of slag from one heat readily illustrate the changes I have described:

No. 1 is the oxidizing slag containing iron manganese and phosphorus oxides. This slag was skimmed off at the end of the oxidizing period.

No. 2 was taken thirty minutes after adding materials for the second slag.

No. 3 was taken forty minutes after the second.

No. 4 was taken twenty minutes after No. 3, and after all additions had been made to the steel.

The analyses of these slags are as follows:

	SiO_2	FeO	MnO	P_2O_5	CaO	MgO	S
No. 1	17.45	16.33	9.02	1.98	48.49	6.86	trace
No. 2	28.05	1.99	1.06	0.48	58.17	9.63	0.85
No. 3	26.82	0.76	0.70	0.37	60.04	8.98	0.71
No. 4	28.70	0.52	0.68	0.28	58.40	8.53	0.89

The analysis of the final slag, I believe, is more free from oxides than the analysis would show, for any minute particles of metallic iron or manganese held in suspension in the slag would be reported by the chemist as oxides of those elements.

DUPLEX AND TRIPLEX PROCESSES

The Electric Furnace process as described is the one in common practice, but variations, of course, are numerous, depending upon materials and equipment available. The most notable variations are those designed to produce greater tonnage at less cost, and are known as the "Duplex" and "Triplex" processes.

The Duplex process consists of melting a charge of pig iron and scrap in an open hearth furnace, preferably of the tilting type, accomplishing the necessary oxidation in this furnace, then transferring the molten steel to an electric furnace and subjecting it only to the reducing period.

The Triplex process is carried out with molten iron, first removing carbon, manganese, and silicon in an acid bessemer converter, transferring it to a basic open hearth and thence to the electric furnace for the final, or reduction stage.

Both of these processes will reduce the time of making an electric furnace heat to about one-third of that required where cold scrap is charged. This is no doubt the most economical procedure where the differential in price between pig iron and scrap is not excessive, or where coal, gas or oil fuel is cheaper than electric fuel. In the steel-making districts of the country electricity for melting scrap will not, in normal times, offset the entire cost of materials necessary when using other fuel. Similarly, the open hearth, as an oxidation process, is more economical than an electric furnace. It therefore follows that, to employ the electric furnace for only the one operation which cannot be obtained in any other steel-making process is the economical procedure, until the conditions of our immediate future change.

CONCLUSION

In drawing a comparison between metallurgical features of the electric furnace process of making steel compared to the open hearth and crucible we find the following:

1. All functions of the open hearth are readily obtained in an electric furnace.
2. The basic principles of the crucible process may be secured in an electric furnace.
3. The open hearth cannot secure the deoxidizing and desulphurizing conditions of an electric furnace.
4. The loss through oxidation of iron and alloys is greater in the open hearth.
5. Materials for a crucible charge must be high grade, analyzed materials, whereas an electric furnace charge needs only to be ordinary commercial materials.
6. Sulphur, phosphorus and manganese cannot be reduced in the crucible, but are readily removed in an electric furnace.
7. Temperatures in excess of the open hearth and crucible processes are easily secured on the electric furnace.

It is therefore possible in electric furnaces to start with materials of an inferior grade and produce steel of a quality equal to that of the crucible process. Every metallurgical feature of both open hearth and crucible processes is easily obtained. It must, however, be understood that in producing steel from an electric furnace the desirable metallurgical features must be introduced. The fact that steel is made in electric furnaces is not an indication that it is of crucible quality. Quantities of steel to-day are being made in electric furnaces but by the open hearth process, and still greater quantities are being produced according to the metallurgical chemistry outlined but without regard to physical metallurgy. That valuable asset of electric furnaces, unlimited temperature, can ruin their product if not properly used. What immediate effect this and the present large percentage of electric-furnace steel going into so-called commercial work will have on the future production of small castings and high-grade alloy and tool steels it is impossible to estimate, but eventually, it must be the furnace for high-grade steel production, because metallurgically and economically the principles more nearly approach the ideal requirements of the metallurgist than any in use to-day.

THE PORT OF PHILADELPHIA*

By GEORGE S. WEBSTER

Director, Department of Wharves, Docks and Ferries

THE great world war has demonstrated the total inadequacy of our transportation systems and the necessity of expanding and modernizing the terminal facilities both on land and water.

When America entered the war, large contracts were entered into by the Government for the manufacture of ordnance and army supplies and the material was being rapidly accumulated without adequate facilities for storage while awaiting shipment; and it soon became evident that many of our ports lacked the necessary terminal facilities required for this extraordinary demand. A Committee of Engineers was appointed under the Council of National Defence, and studies were made of the conditions of all the ports along the Atlantic seaboard and the possibilities which they offered for immediate expansion and development. Extensive additions were authorized, their construction commenced under Government supervision, and the existing facilities owned and controlled by states and municipalities were immediately requisitioned and brought into service. Even these failed to meet the emergency conditions; but they did emphasize the necessity for greater development of the ports in this country.

We will, however, confine our remarks at this time to the important part which the port of Philadelphia has taken, and is capable of still further taking, in the problems of oversea shipments.

When we speak of the port of Philadelphia, we must understand the term as applicable to that territory extending along both banks of the Delaware River from tidewater at Trenton to the state boundary line at Marcus Hook—this including metropolitan Philadelphia and embracing many smaller towns adjacent thereto which are contributing parts of this industrial centre.

The port of Philadelphia is administered by two departments—one, the Department of Wharves, Docks and Ferries of the city of Philadelphia, which has jurisdiction of the waterfront and supervises the building, extension, maintenance and use of all wharves, piers, bulkheads and other harbor structures within the city limits; the other, the Board of Commissioners of Navigation, a state body, which has jurisdiction over the waterfront within the limits of the state of Pennsylvania and outside the city of Philadelphia, with power to make regulations governing the stationing and anchoring of ships and vessels within the entire limits of the port, to perform the functions of harbor master, to license and regulate Pennsylvania pilots, etc.

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* Tuesday luncheon, November 19, 1918, at the Engineers' Club.

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Ports are in competition for trade as actively as firms and individuals engaged in business enterprises, and it is essential to present their advantages to the commercial and shipping interests in order to secure the fullest coöperation and support; and the ports which show economic superiority in the conduct of trade are the ones which will profit most.

While the port of New York is located near the ocean and possesses certain advantages for passenger traffic, the port of Philadelphia, located on the Delaware and Schuylkill Rivers, presents superior advantages for the shipment of manufactured products abroad. Its location is in the centre of a district rich in natural resources, and it is the logical outlet, geographically, for a vast territory to the westward. These conditions have given it supremacy as a centre of diversified manufacture, and unquestioned leadership in some of the most important productive activities of the nation.

The war with Germany emphasized the value of Philadelphia as an economic industrial centre, with exceptional opportunities for still further expansion and development. Owing to the opportunities at hand in and about this city, many large industries engaged in every branch of war work found the conditions so entirely satisfactory that they sought this locality. As result, the various War Boards at Washington found it necessary to discourage the establishment of new industries, because of the lack of adequate railroad transportation to carry the necessary raw materials and other supplies, and also the absence of housing accommodations for the skilled mechanics and laborers required at these industries.

To emphasize this statement, I have but to refer to the great growth in the shipbuilding industry along the Delaware River front. Existing plants were enlarged and new plants established, so that at the present time we have along the banks of the Delaware River eleven large shipyards, containing about 140 shipways and employing more than 100,000 persons; and in these yards it is claimed that over 40 per cent. of the ships now being built for our merchant marine will be constructed.

John C. Jones, Chief of Ordnance for the District of Philadelphia, in a recent newspaper interview, reported that 50 per cent. of the entire output of the Ordnance Department is manufactured in this district and that more than a thousand manufacturers in almost as many different lines, hold Government contracts in the metropolitan area of Philadelphia.

With the Philadelphia district's enormous production of goods for oversea shipment, it would appear a wise and economical course to ship them through this port. Both the Delaware and Schuylkill Rivers offer splendid facilities for handling all these products. The channel of the Delaware River is thirty feet deep at low tide, and the United States Government is working upon a project which is 50 per cent. completed, and which, when finished, will secure a depth of thirty-five feet. The Schuylkill River is now being improved by the United States Government also, so that it will shortly have a channel twenty-six feet deep. These rivers are easily navigable, both day and night, for the largest freight carriers engaged in transatlantic business.

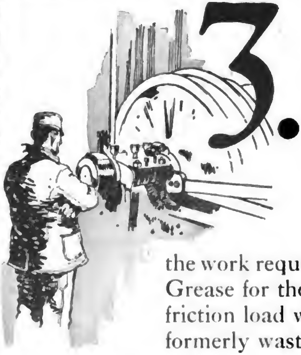
There are three trunk railroads entering the city with facilities for directly reaching the waterfront and discharging cargoes direct from pier to vessel, thus eliminating the expense of all lighterage charges in this port. Provision has also been made by the construction of a great commercial avenue along the riverfront for reaching the piers direct from all sections with motor trucks; and to connect the water and rail transportation systems, there are available a number of large municipal, railroad, and privately-owned piers. Those piers recently constructed by the city are generally of the two-deck type, built of reinforced concrete, and equipped with the most modern appliances for the rapid handling of freight.

Realizing that those ports which were the best equipped to handle commerce would be likely to secure the future trade of the country, the city of Philadelphia, early in 1914, entered upon a comprehensive plan for the development of its waterfront through an agreement with the railroad companies, which calls for the abolishment of grade crossings in South Philadelphia; provides for the extension of the belt-line railroad system around the southern section of the city; and the construction of two large terminal car storage and classification yards—involving in all an expenditure of upwards of twenty-four million dollars. In furtherance of this plan, the Councils of the city authorized the creation of a loan of ten million dollars for the erection of a number of large piers in South Philadelphia. The work upon the construction of these piers has already been commenced, and the first of them—in the Moyamensing group—known as McKean Street Pier, said to be one of the finest piers on the Atlantic coast, has been completed and is ready for service.

Also, a modern pier is approaching completion at the foot of Cherry street, north Delaware River, which is so designed that it may be used either for transatlantic or coastwise traffic.

The construction of other piers by the city—the plans for which were prepared and bids advertised for

THIS IS THE THIRD OF THE 10·GOOD REASONS



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—was delayed, owing to war conditions, the authorities at Washington deeming it wise to utilize in the emergency all available material for work directly connected with the war program, including the piers now under construction on Government-owned property. Therefore the city's project was not pushed in competition with the Government's demand for materials.

Now that the war is drawing to a close, and the demands for the readjustment period are claiming attention, it is the purpose of the city to proceed with its program of construction, it being confidently expected that the commercial development of the country will require these increased facilities. As the Government is building a great merchant marine, it is essential that there shall be adequate port and terminal facilities to meet the demand for this shipping. We therefore expect to place under contract the pier at Kenilworth street, which is located in the centre of the city, in a section that will make it especially available for oversea shipments; as well as a number of the piers in the Moyamensing group, near Greenwich Point, in the southern section of the city.

We fully appreciate the fact that the mere construction of facilities will not bring trade to the port, but that, in order to secure results, we must have the coöperation of the manufacturer and the shipper; and it has been the earnest effort of the Department of Wharves, Docks, and Ferries to point out, not only to our citizens but to the whole country tributary to this port, the advantages which we possess, and the benefits which will accrue through united action in utilizing these facilities.

We are confident that, with proper civic courage and a faith in the future of this port, we can secure greater railroad coöperation and that the functions for which the Belt Line Railroad was created can be brought into fuller use.

It has been suggested that the city should take over the Hog Island shipyard, and establish a great terminal at that point. As the officials of the United States Shipping Board have recently declared that it is the purpose of the Government to continue the shipbuilding program for a number of years, this yard will be an essential in that program, and the suggestion that it be taken over for a port terminal seems a little premature at this time in the absence of any definite proposition; especially as this territory is not at present within the city limits, and inasmuch as the city now owns sufficient waterfront upon which to build a large number of modern piers to carry out a policy of port expansion which has been carefully mapped out and agreed upon. If, in the wisdom of Congress, at a future time it is found desirable, in readjusting the tariff regulations in this country, to establish free ports at any of the Atlantic coast cities, this site might lend itself admirably to the proposition.

The United States Government, in carrying out its policy for the future, has purchased in the southern part of the city a tract of ground upon which it is now constructing two large piers for the accumulation of cargo for oversea shipments. They are to be used by the Quartermaster Department. These piers are of such size as to deserve special mention at this time, one being 290 feet wide by 1500 feet long and the other 290 feet wide by 1340 feet long; both of the three-deck type and having railroad tracks extending out the entire length of the deck. Both piers will be equipped with the latest mechanical appliances for the rapid handling of cargo. Immediately back of these piers it is the intention to erect storehouses, and a large freight-car classification yard, which will permit of the rapid replenishment of cars on the piers during the time of loading and unloading of vessels. We understand it is the purpose of the Government to continue the ownership of this property, but after the war emergency has passed, to lease it for commercial uses.

During the war all of the steamships of the country were taken over by the Government, and the established lines, therefore, suspended regular operations; and the municipal piers from which some of the lines operated were taken over by the Government for its purposes. Upon return to normal conditions, it is expected that these lines will be reëstablished, and that new lines will seek facilities. Already we are receiving inquiries from steamship lines who are planning for the future and are looking to this port as the most advantageous place at which to establish terminals. To meet these demands, it is our intention to utilize the existing piers so far as possible and to proceed rapidly with the construction of additional piers for the increased business which we hope will locate here, for it is certain that if we do not have the facilities ready to offer we cannot hope to secure the trade; and we are convinced that in order to secure an increased growth of commerce it is essential that we shall keep our facilities, if anything, ahead of the immediate demands.

We sincerely trust that we may be able to arouse our citizens to the opportunities which lie at their door, and to secure their enthusiastic support in building up the business, for we are a great manufacturing centre and must depend on outside markets for many of the productions which are in excess of the needs of our own country. If our city is to continue to grow and its industrial population kept continually employed, there must be no slackening of our industries, and ample markets must be obtained.

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THE AMERICAN MERCHANT MARINE *

By LIEUT. COMMANDER STEVENSON, U.S.N.R.F.

President of the Society of Naval Architects and Marine Engineers

THE WORLD'S SHIPPING TONNAGE

THE entire merchant tonnage of the world in 1916 did not exceed 50 million gross tons. Of this there has certainly been destroyed by submarines and casualties not less than 14 million gross tons, leaving of the original quantity not over 36 million gross tons. During 1917 and 1918 there will have been built at most 5 million gross tons, making a total available tonnage of only 41 million gross tons. Following the normal increase per annum there should be available at the beginning of 1919 at least 55 million gross tons. From this statement it appears that there will be, at the close of the year 1918, a deficit of at least 14 million gross tons, without taking note of the depreciation and repairs which the excessive hard usage of ships during the war will have made necessary.

It is not intended that these figures shall be considered exact, but they are sufficiently so to demonstrate the great necessity still existing for ships; and further to show that our own shipyards must still be urged to their utmost capacity in order that the now important American merchant marine shall be upheld in the future.

AMERICAN SHIPYARD PRODUCTION

In the year ending June 30, 1908, the entire production of our shipyards was 614,000 gross tons, the greatest previous to 1915; but in the year ending June 30, 1915, the production fell to 225,000 gross tons, the smallest output in seventeen years. In 1916, there came an enormous demand for ships, not only from our own citizens but from foreigners as well.

When the United States entered the war in April, 1917, it became apparent that there was hardly a more important element for winning the war than ships, and the United States Government, through the agencies of its Shipping Board and Emergency Fleet Corporation, immediately proceeded to encourage the building of many new yards as well as the enlarging of the old yards, with the result that there are now about 200 shipyards, instead of 66 as in November, 1916.

During 1917 there was an output of 800,000 gross tons and the output for 1918 will apparently be about two million gross tons actually delivered and officially numbered. The increase in our registered shipping during the fiscal year ending June 30, 1918, was 1,053,481 gross tons, more than double that of any previous year and something over the total increases for the first three years of the war combined. At the end of this year there will be over ten million gross tons of shipping under the American flag, or nearly double the amount of three years ago.

NEW METHODS

The demands upon our facilities for furnishing the usual materials for ships and the lack of men capable of building ships in the usual manner combined with the extraordinary need of ships, and more ships, to carry on the war has led to experimenting in building large vessels of other than the usual wood and steel materials.

The successful use abroad of moderate sized boats built of concrete reinforced with steel has led us to go much further, resulting in the building of the "Faith," a concrete ship of about 3,000 gross tons, and placing by the Emergency Fleet Corporation of contracts for 42 concrete ships totalling about 200,000 gross tons.

The details, advantages and disadvantages of building reinforced concrete ships have received a great deal of attention from the officials of the Emergency Fleet Corporation, and it is fair to presume that their investigation has warranted the contracting for four ships of this class of about 2,500 gross tons and 38 ships of about 5,000 gross tons each.

This same question has been also under examination and discussion in Great Britain and naturally personal designs and views differ materially. Having had no experience in concrete construction and noting the different proportions of steel in several designs and acknowledged contrasts in carrying capacity and speed with like power, I feel that the concrete sea-going ship is still an experiment and that it is quite possible that the emergency which promotes the building of these ships will have vanished before those contracted for will have performed much service. I note with pleasure that there will be presented at this meeting a paper from an authority on the subject, one who has carefully studied the whole subject technically and practically.

Another novelty even more novel than the concrete ship is the proposed electrically welded ship which has now been under consideration for several months. There has been a vessel (perhaps more than one) manufactured on this plan in Great Britain, but the barge is so small that nothing is proved so far as the building of ocean-going ships is concerned. Electric welding certainly has proved successful in many places and under peculiar conditions, so that the proposed construction of a full size section of a large cargo steamer for complete tests of the method is both interesting and satisfactory. There is also a paper by an authority on this subject which will be especially interesting.

The fabricated cargo ship and the shipyards for building same will also receive at this meeting well-deserved notice, for nowhere has the broad vision of men along these lines been exercised more than in our own country.

RECORDS

Records of various processes have from time to time been noted. The number of frames erected in a day, the number of rivets driven; the few days that have elapsed between the laying of the keel and the launching, and again between the launching and the trial trip; the lineal

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* Extract from Presidential address at the annual convention of the Society of Naval Architects and Marine Engineers, held in the Witherspoon Building, Philadelphia, November 14-15, 1918.

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amount of caulking both on wood and steel ships, and so on to absurdity.

We venture to say that in every instance of these special records there has been special preparation that the records shall be made. The fact remains that the general results attained in the long run are not in accordance with the records and it were better to remember that 400 rivets for every gang for a day's work is a more satisfactory performance than an occasional 1,000 or more rivets.

It is, however, to be said in justice, that the performance of finishing a ship in an unusually short time and the performance repeated over and over as has been done, is worthy of the highest commendation.

THE FUTURE

I have said nothing about the Navy, for it is evident from the statements published from time to time that the interests and upbuilding of the Navy have not only been well taken care of in the recent years of the great war, but that they will also be as well advanced in the future.

It is to the American merchant marine that we must particularly attend. The shipyards in which our naval vessels have in the past been built will also build what will be required for the Navy of the future. They will as well produce their proportion of merchant vessels, and in addition we now have all of the new shipyards. Our shipyards have produced during the year a greater tonnage of merchant vessels than was ever heretofore in any one year produced in the yards of the greatest shipbuilding nation in the world. The United States has spent and contracted to spend enormous funds, primarily to help put down the war and incidentally to place upon the seas a great tonnage under their flag.

Now that the inevitable end of the great war is rapidly approaching, the problems following the destruction and disorganization caused by the war demand the attention of our best ability and judgment. I pass all of the problems not in themselves specially pertaining to this Society. The one great problem for us to consider is that of the future of our merchant marine and what is to be done for it.

You who are owners of ships and shipyards, and you who design and construct ships cannot be indifferent to this question. There are at present in service, as has been stated, ten million gross tons of American merchant ships, double the amount three years ago, and there is a capacity in our yards for building in addition to the ships for the Navy at least three million gross tons per annum. Some of these yards, of course, build wood ships which will be useful coastwise if not across the seas; but when the war is really over, shall we as a nation supinely, as in the past, permit the other nations of the world to carry our entire commerce overseas?

It is incredible that any administration of the United States Government shall thus sacrifice the great funds and efforts, individual and collective, that have been expended in the past two years to build up facilities, to educate men, and women too, in order that we may have and operate ships of our own; and if there are laws upon our statute books that prevent our reasonable operation of ships, they must be amended; if our loading, unloading and other port facilities are not what they should be, they must be changed; if there is anything which interferes with our progress upon the seas, it must be removed, and if there is anything yet lacking to advance this progress, even government ownership, or private ownership aided by a judicious government, it must be developed not for the advantage of any section or coast, but for the needs and advantage of our whole nation.

I recall at this point the wild statements made early in 1917 as to our promised ship production. No one familiar with our business was deceived; but when the summer of that year had passed, and numerous yards had been established and the great number of fabricated ships had been contracted for, our hopes were raised that there would be during this year 1918 a production of ships in our yards considerably greater than ever before produced in one year in any other single nation. We have not realized these fond hopes, but I ask you to consider what has been done in the country besides building ships.

Think of the enormous tasks accomplished in the past twenty months, three of which were the hardest winter months ever known in this country. Think of the cantonments and camps built for soldiers, sailors and aviators; the raising of an army of three million men and the manufacturing of clothes, guns, artillery, munitions and supplies for such army; the despatching "over there" with the aid of our allies of an army of two million men and all of the impedimenta of war besides; the further extraordinary work done by the several aid associations, the Red Cross and others; and with it all, the raising of a fourth Liberty Loan of six billion dollars in three weeks, following the raising of nine billions in the other loans and every one of the loans oversubscribed.

Think of these accomplishments far greater than ever before performed by any nation in the same period of time, and you will conclude that building the yards and two million gross tons of ships in twelve months while all of the former program was also being carried on is an additional accomplishment worthy of notice and praise.

RECONSTRUCTION IN PHILADELPHIA AFTER THE WAR*

By ALBERT N. HOGG

Assistant Cashier, Corn Exchange National Bank, Philadelphia

THE banker must necessarily be a student of conditions in various lines. He especially will observe local industrial and commercial development, and will perceive running through that development, like the woof in the warp, the things that constitute many other factors in community upbuilding.

Human nature, after all, is very much the same;

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* Luncheon address, Engineers' Club of Philadelphia, Tuesday, September 3, 1918.

—*Since 1792*

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And it was the confidence of these early leaders, who won during the days when nothing was certain, that has ever since been an Inspiration and an Incentive.

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energy is just as potent a force in the Philadelphia citizen as it is in the man who lives, for instance, in Chicago—the difference, if there is one, is largely psychological. I make this statement without any reservation. The psychological condition in Philadelphia is due primarily to the fact that the existence of some three hundred and seventy-five thousand separate homes has prevented a free interplay of that social and community spirit which recognizes no barrier in a neighbor's back fence. "A man's home is his castle" is an attractive and trite saying; but when our thousands of business men retire each within his separate castle, he becomes as a community factor, apart and alone. He is quite content to assume the role of critic in all things that make for community uplift and then to let "George do it" when the question of his own duty in the premises confronts him.

The psychological condition is also responsible for the lack of a broad commercial development of the city. It retards us from assuming the higher commercial position to which our industrial resources logically entitle us. Not only has there been lacking proper coördination of and coöperation between our varied business interests, but there has been lacking broad individual action also.

We have, I venture to say, our full share of mechanical and industrial engineers; what we have lacked has been commercial engineers, if that term is permissible, Hamburg, the greatest port in Europe before the war, is largely a port of transmission. The location of Hamburg, over eighty miles from the sea, is not unlike that of Philadelphia.

New York, with over ninety steamship lines to all quarters of the globe, with a vast reservoir of banking capital and foreign exchange facilities, making it to-day the money centre of both hemispheres, is essentially a commercial and financial centre. Philadelphia, by contrast, has been thus far an industrial and manufacturing centre. The fact, nevertheless, remains that local enterprise has been growing beyond the limitations of old banking lines, and it is quite true to-day, I think, that our ideas of banking requirements need revision. Philadelphia's record for conservative banking has long been an enviable one. New York may be said to be quite as conservative—the points of distinction are the larger legal loaning limit which many New York institutions enjoy because of their larger capital and the existence of many private banking concerns with ample capital for the promotion of construction projects. To-day, precedent proves nothing, and old ideas of proportion must needs be reconstructed if a community is to be in the van of progress.

We have not capitalized our opportunities, commercially, in the same proportion that they have been capitalized industrially, while the subject necessarily comprehends those other great factors which are included in a consistent rate of community development, such as good housing, water supply, rapid transit, parkways, and the various projects all tending to raise the tone of the community as a place to live in and in the improvement of facilities to take care of the working man.

Consider what we have as a base for commercial exploitation: Within a radius of sixteen miles of City Hall there is an area of 767 square miles, and in comparison with larger cities there is less land not available, and less cut up by water areas. In this area there is a population of at least two and a quarter million people and a yearly product, in peace times, exceeding a billion dollars in value. There is a comprehensive scheme devised under a city agreement to utilize the South Philadelphia water front by building pier and wharf terminals. Some millions of dollars have already been expended, which will open up a great area of land in that section for home and industrial development We have thirty-seven miles of water front, a thirty-five-foot channel in the Delaware and thirty feet in the Schuylkill. We have the largest and most varied manufacturing facilities and the greatest labor market in the world; the beginning of a great physical port development supplemented by a natural gateway to the open sea, as well as the greatest shipbuilding centre in the world; and we have almost at our back door, as it were, the greatest steel, coal and cement supplies in the country. Suddenly this great section has been swept along in the tide of a tremendous war business that has carried away old moorings; borne us out, as it were, into the open sea of international trade and developed almost over night many of the great natural advantages which have been slumbering here for generations, awaiting, it is to be regretfully admitted, this great national crisis to make them spring into life.

In the commercial course of Philadelphia we are now nearing the point where it will be determined whether the momentum of the present abnormal activity carries us into a new and broader channel of commercial development and whether our psychological condition as well as our commercial viewpoint will undergo the reconstruction process necessary to enable us to realize our commercial possibilities. It is to be seen whether the new idea of coöperation which is abroad in the land will find lodgment in the minds of our business men; whether our business organizations, such as the Chamber of Commerce, will get together in this new spirit of coöperation and help swing into line the many factors which enter into the solution of the problem—to fuse the complex elements that enter into the reconstruction problem facing Philadelphia after the war; whether, in a word, we shall pool our resources and efforts. In a municipal sense, splendid provisions for a proper correlative development have been made. The great question, it seems to me, is the psychological one: the evolution from an insular viewpoint on the part of our people, individually and collectively, to a state of mind that sinks narrow rivalries in a broad effort which has for its base the necessary element of thorough coöperation.

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PHILADELPHIA MONTREAL LONDON

COMMITTEE ON PAPERS

LEWIS H. KENNEY, CHAIRMAN

REGULAR MEETING

at Witherspoon Hall

Tuesday, December 17, 8.15 P.M.

Mr. Frederick K. Morris

of the Department of Geology, Columbia University

will present a paper, illustrated with motion pictures and lantern slides, entitled

"THE FOURTH YEAR"

Members of the Club and of affiliated societies are privileged to invite ladies to the meeting.

Mr. Morris will present a brief review of the events that led up to the situation that existed at the beginning of 1918. Then, more fully, the 1918 campaign will be considered, the topography of the country, the strategy devised by the Germans in each of their great drives, and the manner in which these attacks were met; what places the Allies yielded; which lines and places they stubbornly held; the situation when the attack was renewed along the Marne salient on July 16, and the series of counter-offensive strokes by which the Allies regained and held the initiative.

TUESDAY NOON LUNCHEONS

The following schedule of speakers has been arranged:

December 3	Dr. Lightner Witmer, Department of Psychology, University of Pennsylvania.
December 10	Mr. Thomas F. Armstrong:—**"Guilty or Not Guilty."**
December 17	Commander F. G. Coburn, U. S. N.:—**"Aeroplane Construction."**
December 24	Dr. M. W. Franklin:—**"Peace."**
December 31	Mr. Fullerton L. Waldo:—**"America at the Front."**

SECRETARY'S NOTICES

A REGULAR MEETING of the Club will be held **Tuesday evening, December 17, 1918, at 8.15, at Witherspoon Hall.**

H. A. STOCKLY,
Secretary.

ABSTRACT OF MINUTES

of the Business Meeting of the Club held Tuesday evening, November 19, 1918:

The meeting was called to order by President Stevens at 8.25 P.M., at Witherspoon Hall. About 600 members and guests were present.

The minutes of the Thirty-eighth Annual Meeting, held May 21, as published in the "Journal," were approved.

Announcement was made of the election of eleven applicants to Active membership and two to Junior membership.

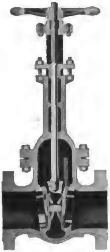
The following list of names submitted by the Board, in accordance with the By-laws, to constitute a Committee on Nominations for the current year, was accepted:

F. C. Dunlap, *Chairman*
W. P. Dallett
Carl Hering
H. P. Liversidge
George B. Taylor
William S. Twining
D. Robert Yarnall

The paper of the evening, entitled "Overseas Experiences in Italy," was presented by Mr. George W. Braden, former Y.M.C.A. Director of Athletics and Recreation for the Italian Army.

A unanimous vote of thanks was extended to Mr. Braden.

The meeting adjourned at 10 P.M.



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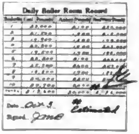

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ABSTRACT OF MINUTES

of the Regular Meeting of the Board of Directors, held

NOVEMBER 12, 1918

The meeting was called to order at 7.15 P.M., with President Stevens, Vice-President Wagner, Directors Spencer, Swaab, Parker, James, Lauer, Quimby, Terrell, Newkirk, Past-President Carter, Treasurer Kenney and Secretary Stockly in attendance. Vice-President Andrews, Directors Gant, Murphy, Lee, Douglas, Barr, Past-Presidents Ledoux and Vogleson were excused. Vice-President Eglin, Directors Connell and Long were absent.

The minutes of the Regular Meeting of June 11, Special Meetings of July 9 and August 6, Organization Meeting of June 19 and Regular Meeting of October 8, as issued to the members of the Board, were approved. Actions taken at these meetings, together with actions taken by letter ballot in September, were also approved.

REPORT OF THE PRESIDENT

Since the last Board meeting, the will of the late Harriet M. Prevost, widow of Sutherland Prevost, former member of the Club, was probated, by which will $10,000 was bequeathed to the "Engineers' Society of Philadelphia." Notification was received from the trustees, the Fidelity Trust Company, inquiring whether the Club desired to present a claim. This was done, and recently the auditing judge of the Orphans' Court rendered a decision in favor of the Club's claim.

President Stevens recommended that the bequest be placed in trust and that the By-laws be revised, creating a board of trustees whose function it would be to care for these, as well as similar bequests; and the recommendation was referred to the Committees on By-laws and Finance.

The Philadelphia Section, Association of Iron and Steel Electrical Engineers, have notified us of the appointment of the following representatives on our Board and Committees:

Board of Directors	D. M. Petty
Committee on Meetings	Linn O. Morrow
Committee on Public Relations	George W. Richardson
Committee on Publications	A. J. Standing

REPORT OF THE SECRETARY

Nine resignations from members in good standing were presented and referred to the Committee on Increase of Membership.

The following deaths were announced:

John Downham	Active Member, died Oct.	6, 1918
Silas G. Griffith	Active Member, died Oct.	10, 1918
W. E. Herring	Active Member, died Oct.	9, 1918
Wm. A. Moncure	Active Member, died Oct.	2, 1918
Lieut. F. L. Prichett	Active Member, died Sept.	6, 1918
Henry S. Raub	Active Member, died Oct.	8, 1918
DeWitt C. Smith	Active Member, died Oct.	14, 1918
George M. Spear	Active Member, died Oct.	4, 1918
Ensign J. R. Zeckwer	Active Member, died Oct.	15, 1918
James Rowbottom	Active Member, died Nov.	6, 1918

A copy of the minutes of the first fall meeting of the Faculty of the Towne Scientific School, University of Pennsylvania, pertaining to the late Dr. Edgar Marburg, was presented.

REPORT OF THE COMMITTEE ON MEMBERSHIP

The Committee presented a report, and the following were elected:

To Active Membership:
Alvin Ward King
James W. Paxton
Fred M. Ryder
To Junior Membership:
Alfred A. Adler
Harry A. Billig

REPORT OF COMMITTEE ON PAPERS

The Society of Naval Architects and Marine Engineers held their Twenty-sixth Annual Meeting at Witherspoon Hall, November 14 and 15, with registration headquarters at the Gold Room, Bellevue-Stratford. We have corresponded with Mr. William G. Coxe, Chairman of the local Committee; and Mr. Stevenson Taylor, President of the Society, has extended a cordial invitation to our members to attend their meeting. We are issuing the invitation to our membership with the notice of our November 19th meeting.

The Committee is of the opinion that it is desirable to occasionally arrange for addresses at our Tuesday Noon Luncheons on municipal engineering subjects for the information of our members. These addresses might result in the Club's taking some official cognizance of these engineering undertakings, and we might in this way, by means of the press, keep the Club before the public.

Our attention has quite frequently been called during the past few months to the reprinting in various magazines and technical journals throughout the United States of articles published in the Club "Journal." Credit is usually given to the "Journal," although in some instances this has not been done; but an inquiry has usually brought forth the response that credit was omitted due to oversight, and proper credit would be given in the future.

COMMITTEE ON NATIONAL SERVICE

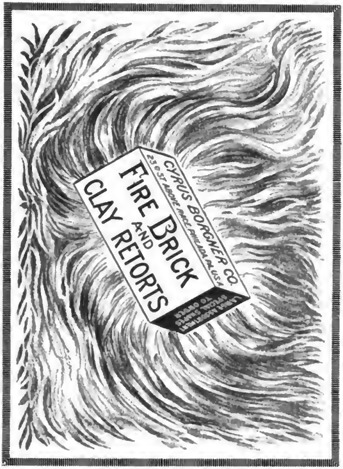
The question of providing a suitable service flag for the Club, which was referred to the Committee by the Board at its October meeting was considered by the Committee, and a new service flag has been purchased and hung outside the Club house.

NEW BUSINESS

It was suggested that an engraved holiday greeting card be sent as soon as possible to the members of the Club in active service. The suggestion was referred to the Committee on National Service, with power to act.

The meeting adjourned at 9.10 P.M.

H. A. STOCKLY,
Secretary.



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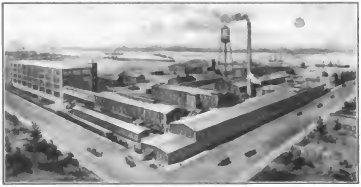

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COMMITTEE ON MEMBERSHIP

PAUL SPENCER, CHAIRMAN

CANDIDATES FOR MEMBERSHIP

Members having knowledge of the candidates are invited to submit to the Committee on Membership before December 9 a confidential expression of opinion as to the eligibility of the candidates; all communications to be addressed, "Chairman of the Committee on Membership, Engineers' Club, Philadelphia," marked "Confidential."

All applications are on file at the Club and can be referred to by any member.

FOR ELECTION TO NAVY MEMBERSHIP

DOUGLAS LYLE FURNESS

Machinery Division, Navy Yard, Philadelphia, Pa.
U. S. Naval Reserve Force, Lieut., J. G., for electrical duty.
Proposed by Charles Penrose and W. H. Connell.

FOR ELECTION TO ACTIVE MEMBERSHIP

WILLIAM W. BARNES

1814-16 Market Street, Philadelphia, Pa.
District Manager, Davis-Bournonville Co., Jersey City, N. J.
Proposed by William E. Worcester, Wm. P. Parker and Chas. G. Gery.

RUSSELL H. KENT

Clifton Heights, Pa.
Engineer and Executive, with The Kent Manufacturing Co.
Proposed by Walter Y. Shaw and Baxter Reynolds.

CLIFTON LEE, JR.

Emergency Fleet Corporation, 140 North Broad Street, Philadelphia, Pa.
Travelling Engineer, Emergency Fleet Corporation.
Proposed by Thos. W. Clarke and F. W. Dean.

HENRY G. NICHOLS

Glenside, Pa.
Salesman, Square D Co.
Proposed by J. C. Vogel and Linn O. Morrow.

LINGAR STROTHER RANDOLPH

Care of U. S. Shipping Board, 140 North Broad Street, Philadelphia, Pa.
Mechanical Engineer, with U. S. Shipping Board.
Proposed by H. F. Sanville, J. F. Stevens and Paul Spencer.

JOHN HECTOR SCHLOMER

Care of Roberts' Filter Mannfacturing Co., Frankford, Philadelphia, Pa.
Chief Army Inspector for U. S. A.
Proposed by Jesse W. Roberts and H. F. Sanville.

GEORGE H. SHAW

5910 Pulaski Avenue, Philadelpia, Pa.
Civil Engineer, Emergency Fleet Corporation, Philadelphia.
Proposed by B. A. Haldeman and Isaac S. Walker.

BENJAMIN FRANKLIN THEOBALD

414 North Third Street, Philadelphia, Pa.
Salesman and Designer, Alexander Brothers.
Proposed by Herbert B. Allen and S. M. Swaab.

DILLON BROOKFIELD WILSON

Care of General Electric Co., Witherspoon Bldg., Philadelphia, Pa.
Sales Engineer.
Proposed by Baxter Reynolds and H. F. Sanville.

FOR ELECTION TO JUNIOR MEMBERSHIP

WALTER BAIRD

1521 North Edgewood Street, Philadelphia, Pa.
Mechanical Designer, Niles-Bement-Pond Co.
Proposed by Sydney Buckley and John H. Nuttall.

L. DREW BETZ

Care of E. F. Drew & Co., Inc., Swanson and McKean Streets, Philadelphia, Pa.
Manager and Chemical Director, E. F. Drew & Co., Inc.
Proposed by Thos. G. Lovegrove, Walter S. Barry and Arthur Claassen, Jr.

THOMAS J. FINE, JR.

5031 Chestnut Street, Philadelphia, Pa.
Chief Yeoman, U. S. N. R. F.
Proposed by K. Warren Heinrich and Henry C. Adams, Jr.

ABRAHAM H. HIRSCH

1611 South Fifth Street, Philadelphia, Pa.
Civil Engineer, American International Shipbuilding Co, Hog Island, Pa.
Proposed by Wm. Easby, Jr., and H. C. Berry.

HOMER L. KILGORE

5943 Osage Avenue, Philadelphia, Pa.
Student Engineer, The Bell Telephone Co. of Pa.
Proposed by Charles Wahl and J. D. Ferry.

WILLIAM MacDONALD

5252 Walnut Street, Philadelphia, Pa.
Structural Designer, Niles-Bement-Pond Co.
Proposed by Sydney Buckley and John H. Nuttall.

PRESTON ALFRED REBOK

603 Finance Building, Philadelphia, Pa.
Sales Engineer, Sherritt & Stoer Co., Inc.
Proposed by M. A. Sherritt and J. H. Wood.

NORWOOD VINCENT TAYLOR

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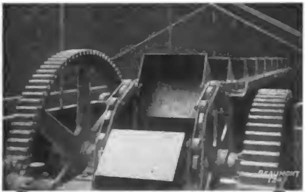

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COMMITTEE ON NATIONAL SERVICE

GUILLIAEM AERTSEN, CHAIRMAN

> *"From these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion; these dead shall not have died in vain."*—Abraham Lincoln.

Barker, Edward Williams	Sergeant	Junior Member	Died March 17, 1918, Camp Meade, Admiral, Md.
Day, Richard F.	Lieutenant	Active Member	Died September 25, 1918, Clermont, France
Hetherington, S. C.	1st Lieutenant	Active Member	Died September 28, 1918, Argonne, France
Prichett, Frederick B.	Lieutenant	Active Member	Died September 6, 1918, France
Prince, Harry Walter	1st Lieutenant	Junior Member	Died June 11, 1918, England
Zeckwer, J. R.	Ensign	Active Member	Died October 15, 1918, Philadelphia

MEMBERS OF ENGINEERS' CLUB IN SERVICE IN THE ARMY OR NAVY OF THE UNITED STATES, AS OF NOVEMBER 25, 1918

NAME	RANK	CORPS	LOCATION
Abbey, J. F.	Lieutenant	4th Student Co., E. O. T. S.	Camp Humphreys, Va.
Aldrich, J. T.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Allen, H. Butler	Lieutenant	U. S. Ordnance Department	American Expeditionary Forces, via New York
Allen, J. G.	1st Lieutenant	Co. "D," 56th Infantry	American Expeditionary Forces, via New York
Altemus, A. L.	Lieutenant	Co. "A," 78th Engineers	Camp Leach, D. C.
Althouse, A. K.		Co. 5, E. O. T. S.	Camp Humphreys, Va.
Anders, D. W.	Major	Company D, 502nd Engineers	American Expeditionary Forces, France
Andrews, J H. M.	Lieut. Colonel	Ordnance, N. A.	Commdg. Officer, Raritan Arsenal, Metuchen, N. J.
Asplundth, E. T.	Captain	103rd Engineers	American Expeditionary Forces, via New York
Atterbury, W. W.	Brigadier-General	Director-General of Railways	France
Austermuhl, Edward	Utilities Officer	War Department	203 South 4th Street, Philadelphia
Baird, Hobart B.	Captain	307th Engineers	American Expeditionary Forces, via New York
Baker, W. D.	2nd Lieutenant	Aviation Corps	France
Banister, E. S.	Lieutenant	Ordnance Officers' Reserve Corps	Woodbury Bag Loading Plant, Westville, N. J.
Barnes, H. P.		Naval Flying Corps, Mass. Inst. Technology	Cambridge, Mass.
Barnes, F. B.	Master Engineer	Care of S. E. O., A. S., S. O. S. Electrical and Mechanical Department	American Expeditionary Forces, via New York
Bassett, F. H., Jr.		Officers' Training School	Camp Meade, Md.
Bauman, C. U.	1st Lieutenant	Co. "E," 103rd Engineers	American Expeditionary Forces, via New York
Bear, H. K.	Lieutenant	Gas Defense Service	Camp Greenleaf, Ft. Oglethorpe, Ga.
Beatty, L. B.	Ensign	U. S. Naval Reserve Force	705 Parker Ave., Collingdale, Pa.
Bell, Frank F.	Captain	Air Service Flying School	Gerstner Field, Lake Charles, Louisiana
Bergman, G.	Private	Utilities Co., Q. M. C.	Camp Dix, N. J.
Bescherer, P.	2nd Lieutenant	319th Heavy Artillery	Camp Gordon, Ga.
Betus, A. J.	Major		A. P. O. 720, American Expeditionary Forces, via New York
Biester, W. H., Jr.	Corporal	"Co. E." 103rd Engineers	American Expeditionary Forces, via New York
Bishop, A. B.	2nd Lieutenant	Dept. Military Aeronautics	Camp Jackson, Columbia, S. C.
Borden, J. M.	2nd Lieutenant	Ordnance Reserve Corps	Hudson Motor Car Co., Detroit, Mich.
Borresen, W. Y.		315th Infantry	Camp Meade, Admiral, Md.
Boyd, F. F.	Lieutenant Engineer Officer	U. S. Naval Reserve Force	Submarine Base, New London, Conn.
Boyd, G.	1st Sergeant	Gas Service	A. P. O. 717, American Expeditionary Forces, via New York
Bradford, J. S.	Major	103rd Engineers	American Expeditionary Forces, via New York
Bradt, Morris	1st Lieutenant	Ordnance Officers' Reserve Corps	Hqrs. Base Section No. 3, Line of Communication, A. E. F., Goring Hotel, Grosvenor Gardens, London, S. W. 1
Bransome, E. D.	Ensign	Naval Air Service	Naval Station, Pensacola, Fla.
Bream, C. C.	Corporal	103rd Engineers	American Expeditionary Forces, via New York
Breen, J. W.	Captain	Engineers U. S. R.	A. P. O. 702, Amer. Exped. Forces, via New York
Brewer, P. C., Jr.	Lieutenant	4th Regt. Engineers	Camp Humphreys, Va.
Brinton, J. W.	Lieutenant	Quartermaster Officers' Reserve	Depot Quartermaster, Baltimore, Md.
Britt, G. H.	Ensign	U. S. Naval Aviation Repair Base	Eastleigh, England
Britten, D. J.	Captain	Ordnance Officers' Reserve Corps	Inspector of Ordnance, Haddon Apts., Cleveland, O.
Broadhead, Alex		19th Reserve Engineers	American Expeditionary Forces, via New York
Brogan, C. M.		Quartermaster's Corps, Utility Detachment, Barracks "B"	Camp Meade, Admiral, Md.
Brown, J. A.	Major	Ordnance Officers' Reserve Corps	Smithtown, L. I., New York
Brown, N. F.	Major	Railway Engineers	American Expeditionary Forces, care Brigadier General W. W. Atterbury
Brown, P. D.		19th Reserve Engineers	American Expeditionary Forces, via New York
Brown, R. V.	Lieutenant	Q. M. C., N. A., Advanced Section, S. O. S.	American Expeditionary Forces, France
Brown, W. F.	1st Lieutenant	520th Engineers, N. A.	American Expeditionary Forces, via New York
Brown, W. L.	Lieutenant	Winchester Repeating Arms Co.	New Haven, Conn.

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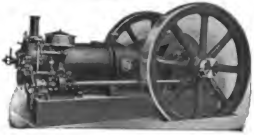

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Campbell, C. C.		Motor Co. 13, Section "B"	Camp Greenleaf, Ga.
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Carson, Walter		32nd Service Co., Meteorological Department	American Expeditionary Forces, via New York
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Essick, P. J., Jr.	Lieutenant	Co. "A," 5th Infantry	Camp Beauregard, Alexandria, La.
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Ferree, D. S.	2nd Lieutenant	Aviation Section, Signal Corps	Ellington Field, Houston, Texas
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Fish, W. N.	1st Lieutenant	Ordnance Reserve Corps	Fort Sheridan, Ill.
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Gallagher, L. B.	2nd Lieutenant	Railway Trans. Dept., U. S. A.	P. O. 717, American Expeditionary Forces, France
Galloway, James W.	Captain	Engineers' Corps	Camp Humphreys, Va.
Gant, H. P.	Captain	Pig Point Ordnance Depot	Pig Point, Va.
Gardiner, F. M.	Lieutenant	U. S. Naval Reserve Corps	Naval Training Base, Cape May, N. J.
Garforth, Ezra	2nd Lieutenant	23rd Regiment, Highway Engineers	American Expeditionary Forces, via New York
Gaum, Carl G.	1st Lieutenant		General Staff, G, 4, U. S. A., P. O. 717
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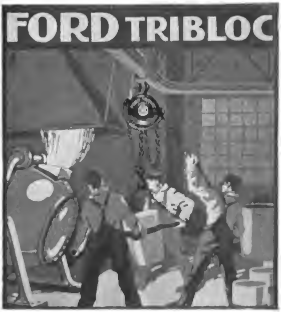
Gest, J. B., 2nd	2nd Lieutenant	Engineer Officers' Reserve Corps	American Expeditionary Forces, via New York
Getz, Ralph F.	2nd Lieutenant	32nd Engineers	Camp Grant, Ill.
Gilbert, W. T.		21st Railway Engineers	American Expeditionary Forces, via New York
Gillam, W. H., Jr.	1st Lieutenant	Ordnance Officers' Reserve Corps	Washington, D. C.
Goldberger, J. L.	Private	12th Co., 1st Road Reg.	Camp Jos. E. Johnston, Jacksonville, Fla.
Goldsmith, H. F.		Naval Aviation Training School	Boston, Mass.
Goodwin, H., Jr.	Lieutenant	U. S. Naval Reserve Forces	Bureau of Naval Officers' Operations, 1729 G St., N. W., Washington, D. C.



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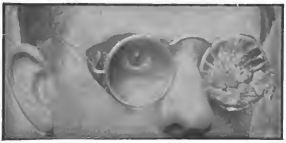

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Grelis, John J.		Officers Material School	University of Pennsylvania, Philadelphia
Gribbel, W. G.	Major	Engineers	Camp Humphreys, Va.
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Hamilton, R. D.	Captain	Ordnance Reserve Corps	Care of T. A. Gillespie Loading Co., So. Amboy, N. J.
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Haydock, Roger	1st Lieutenant	Engineer Officers' Reserve Corps	Washington Barracks, D. C.
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Hollenback, E. E.	Major	109th Infantry	American Expeditionary Forces, via New York
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Hyland, G. N.	2nd Lieutenant	Mather Field, Mills Station	Sacramento, Cal.
Jamison, R. B.	Sergeant		Camp Hill, Newport News, Va.
Jaques, J. D.	Lieutenant	U. S. N. R. F., Public Works Dept.	Navy Yard, Boston, Mass.
Jensen, J. A.	2nd Lieutenant	Chem. Service Section, N. A.	American University Exp. Station, Washington, D.C.
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Kraus, P. T.	2d Lieutenant	55th Signal Battalion, U. S. A.	Amer. Exp. Forces, via New York
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MacMasters, Roy H.		Naval Officers' Training Camp	Cape May, N. J.
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Moon, T. E.	Sergeant	Barracks C—19, O. O. M. I. S.	Raritan Arsenal, Metuchen, N. J.
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Orr, M. W.	2nd Lieutenant	Field Artillery, Separate Detachment	American Expeditionary Forces, via New York
*Otwell, Curtis W.	Colonel	319th Engineers	Camp Fremont, Palo Alto, Cal.
Packer, H. M.	1st Lieutenant	Park Aviation Field	Millington, Tenn.
Park, R. G.	2nd Lieutenant	A. S. A. P.	Vancouver Barracks, Washington
Perry, Edward	Sergeant	Motor Truck Company No. 329	Camp Lee, Petersburg, Va.
Peterman, J. M.	2nd Lieutenant	5th Bn., 152nd Depot Brigade	Camp Upton, N. Y.
Peters, E. T.	Chief Yeoman	Naval Coast Defense	Dept. Public Works, Philadelphia Navy Yard
Pfeffer, H. W.	1st Lieutenant	Ordnance Officers' Reserve Corps	Bethlehem, Pa.
Pickles, W. W.	2nd Lieutenant	U. S. Public Health Service	Extra Cantonment Zone Sanitation, City Hall, Augusta, Ga.
Pierce, D. T.	Major	American Red Cross	France
Pike, Clayton W.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
Pugh, M. R.	Major	21st Engineers	American Expeditionary Forces, via New York
Rader, H.	Lieutenant	Quartermaster's Corps	Washington, D. C.
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Raynsford, C. O.	Captain	Ordnance Officers' Reserve Corps	Washington, D. C.
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Reed, Thomas	Major	Ordnance U. S. A.	New York District
Reeder, W. C.	Major	Ordnance Officers' Reserve Corps	Washington, D. C.
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Roop, J. C.	Captain	17th Engineers	American Expeditionary Forces, via New York
Roth, F. E.	1st Sergeant	Utilities Department, Quartermaster's Corps	Camp Meade, Admiral, Md.
Roush, G. A.	Captain	Inspection Division, Ordnance Dept.	Washington, D. C.
Ruff, A. G.	Ensign	U. S. Naval Reserve Force	U. S. S. "Manchuria," care of Postmaster, N. Y. City
Russell, J. A.	Lieutenant	311th Engineers	Camp Grant, Rockford, Ill.
Ryan, E. J.	1st Lieutenant	Engineer Officers' Training Camp	Camp Humphreys, Va.
Sacks, S. I.		Co. "J," 4th Regiment	Camp Parry, Great Lakes, Ill.
Sanville, L. F.	Private	108th Field Artillery,	American Expeditionary Forces, via New York

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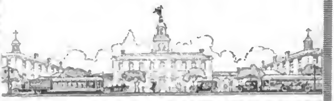

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Satterwhite, R. L., Jr.		Company 20, Naval Aviation Detachment	Massachusetts School of Technology. Cambridge, Mass.
Sauter, W. R.	1st Lieutenant	Ordnance Officers' Reserve	New York Arsenal, Governors Island, N. Y. Harbor
Schaum, O. W.	Aeronautical Mechanical Engineer	Signal Corps, U. S. A.	Lindsey Bld'g, Dayton, Ohio
Schoch, J. B.	Lieutenant	109th U. S. Infantry	American Expeditionary Forces, via New York
Schoff, A. L.	1st Lieutenant	Signal Corps, Land Division	Port Worth, Texas
Schwegler, O. F.		Reserve Officers' Training Camp	Fortress Monroe, Va.
Schweizer, H. W.		Gas Defense Service, Med. Dept., U. S. A.	Washington, D. C.
Scull, M. A. H.	Lieutenant	Railroad Transportation Corps	U. S. A. P. O. 717, American Exp'y Forces, via New York
Shallcross, J. B.	Lieutenant	Ordnance Reserve Corps	Inspection Div., 6th & B Sts., N. W., Washington, D. C.
Sheahan, J. C.	2nd Lieutenant	M. T. S.	A. P. O. 708, American Expeditionary Forces, via New York
Shoemaker, Frederick F.		U. S. S. Suzanne. S. P. 510	Cape May, N. J.
Shuster, W. H., Jr.	Lieutenant	314th Infantry	American Expeditionary Forces, via New York
Sigmund, Paul E.		Hqr., 301st American Battalion, Tank Corps	British E. F., France
Smith, A. H.	Sergeant	Utilities Detachment Quartermaster's Corps	American Expeditionary Forces, via New York
Smith, G. D.	Lieutenant	112th Infantry	American Expeditionary Forces, via New York
Smith, Stanley			Ft. Thomas, Ky.
*Smith, W. S.	Rear Admiral	Navy Department	Special Duty, Naval Consulting Board, Washington, D. C.
Smith, X. R.	1st Lieutenant	Procurement Division, Small Arms Section, Ordnance Dep't, U. S. A.	6th and "B" Sts. Washington, D. C
Spackman, H. S.	Lieut. Colonel	Corps of Engineers, U. S. A.	Hqrs. Cement Mills Companies, American Expeditionary Forces, via New York
Spillan, J. J. D.	2nd Lieutenant	103rd Trench Mortar Battery,	American Expeditionary Forces, via New York
St. John, Everett	1st Lieutenant	Battery "D," 74th Artillery, C. A. C.	American Expeditionary Forces, via New York
Stevenson, W. L.	Lieutenant Commander	U. S. Naval Reserve Force	Care of American Consul, Bordeaux, France
Stokes, D. B.	Major	Quartermaster's Corps, N. A.	Care of Hotel Burlington, Washington, D. C.
*Tawresey, J. G.	Naval Constructor	Navy Department	Construction Officer, Philadelphia Navy Yard
Taylor, H.	Major	304th Regiment Engineers	Camp Meade, Admiral, Md.
Thacher, C. F., Jr.	1st Lieutenant	Co. "A," 32nd Engineers,	American Expeditionary Forces, via New York
Thacher, C. H.	2nd Lieutenant	Co. "A," 510th Engineers' Service Battalion	American Expeditionary Forces, via New York
*Thomas, R. S.	Colonel	22nd Engineers	Camp Sheridan, Montgomery, Ala.
Thomson, H. A.	1st Lieutenant	Care of Utilities Officer	Camp Hancock, Augusta, Ga.
Thorpe, A. W.	Master Engineer	Chemical Warfare Service	Edgewood Arsenal, Md.
Tillson, P. E.	Lieutenant	United States Naval Reserve Force	U. S. S. "Florida" (foreign service)
Tretch, W. E.	Chief Machinist	Steam Eng. School for Engineering Officers	Stevens Institute, Hoboken, N. J.
Truhan, L. J. D.	Ensign	U. S. Submarine Base, Barracks "E"	New London, Conn.
Uhler, W. D.	Lieut. Colonel	Motor Transport Corps	Washington, D. C.
Vauclain, A. C.	Major	Ordnance Officers' Reserve Corps	Watertown Arsenal
Vaughan, D. L.	Captain	Quartermaster's Corps, N. A.	Camp Logan, Houston, Texas
Voegelin, E.		10th Company	Columbus Barracks, Columbus, Ohio
Vogleson, J. A.	Major	Sanitary Corps, N. A.	Camp Joseph E. Johnston, Jacksonville, Fla.
Ward, R. C.	Captain	Hqr's, 34th Artillery Brigade	Fort Adams, R. I.
Warfel, A. C.	2nd Lieutenant	35th Regiment Engineers	American Expeditionary Forces, via New York
Warfel, J. P.	Lieutenant	U. S. Naval Reserve Force	Machinery Division, Philadelphia Navy Yard
Watson, G. L.	Lieut. Colonel	General Staff, C. A. C. of S. G. 2, 1st Army Corps	American Expeditionary Forces, via New York
Webb, Walter Loring	Major	R. R. & C., S. O. S.	American Expeditionary Forces. via New York
Webster, E. L.		Reconstruction Relief Work Friends' Unit of the Red Cross	France
Wentz, E. M.	Asst. Paymaster	U. S. Naval Reserve Force	Care of Postmaster, N. Y. C.
Wheeler, G. C.	Private	Chemical Service Section	American Expeditionary Forces, via New York
Wheeler, Robert C.	Captain	Quartermaster's Corps	Care of Port Utilities Officer, Newport News, Va.
Whitaker, J. H.	2nd Lieutenant	317th Field Artillery	American Expeditionary Forces, via New York
White, W. M.	Major	Engineers' Corps	Camp Humphreys, Va.
White, J. A., Jr	Private	109th Infantry	American Expeditionary Forces, via New York
Wild, H. J.	Captain	Engineer Officers' Reserve Corps	Washington, D. C.
Wilkinson, R. W.		Engineers' Training School	Carnegie Institute, New York
Williams, H. L.	2nd Lieutenant	319th Engineers	Camp Tremont, Cal.
Witte, W. E.	1st Lieutenant	Ordnance Officers' Reserve Corps	
Woerwag, C. A.	1st Lieutenant	Ordnance Officers' Reserve Corps.	Office of Inspector of Ordnance, U. S. A. Ford Motor Co., Highland Park, Mich.
Wood, E. R. Jr.	Captain	18th Field Artillery, N. A.	
Work, Leonard	1st Lieutenant	52nd Aero Squadron, A. S. S. C	American Expeditionary Forces, via New York
Worrell, H. S.	2nd Lieutenant	Coast Artillery School	Fortress Monroe, Va.
Worth, J. G.	Captain	Quartermaster Officers' Reserve	Washington, D. C.
Young, R. L.	1st Lieutenant	Ordnance Reserve Corps	Aberdeen Proving Ground, Aberdeen, Md.
Watt, W. R.		Co. "H," 1st Regt., Section B, S. A. T. C.	University of Pittsburgh, Pittsburgh, Pa.
*Zinn, George A.	Colonel	District Engineers' Office, Custom House	Portland, Oregon

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* Army and Navy member.

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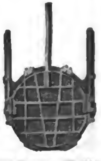

PHILADELPHIA ASSOCIATION OF MEMBERS AMERICAN SOCIETY OF CIVIL ENGINEERS

THE October meeting, which was the annual meeting, was held October 7, 1918; but because of the influenza epidemic, and in obedience to the order of the authorities, it was restricted to members of the Board of Directors. The next regular meeting will be on the first Monday in January, at which time the newly elected President, Mr. F. Herbert Snow, Chief Engineer of the Pennsylvania Public Service Commission, will preside. Mr. Calvin W. Rice, Secretary of the American Society of Mechanical Engineers, and Mr. S. M. Swaab, Member American Society Civil Engineers, will open the discussion of the topic which had been programmed for the October meeting, and a number of members are expected to participate in it. The subject is: "The Relation of the Engineer to the Community, and the Use of the Society to the Engineer." There will undoubtedly be a large attendance to greet the new officers. Informal topics of conversation at the meeting, in view of the important part taken by Civil Engineers in war activities as well as peace-time construction, will undoubtedly lead members into a discussion on the Report of the National Committee on Development, which, in addition to seven members at large, consists of one representative each from the twenty-one Local Associations of the Society, Philadelphia being represented by Mr. Richard L. Humphrey. These engineering specialists will endeavor to solve the knotty problems involved in adjusting the internal organization of the Society to change external conditions as indicated in the following abstract from the Resolutions of the National Society:

> The development and application of the sciences in recent decades have caused profound changes in the social and industrial relationships of all peoples.
>
> The Engineer has been a leader in this progress.
>
> Sociological and economic conditions are in a state of flux and are leading to new alignments of the elements of society.
>
> These new conditions are affecting deeply the profession of engineering in its services to society, in its varied relationships to communities and nations, and in its internal organization.
>
> A broad survey of the functions and purposes of the American Society of Civil Engineers is needed in order that an intelligent and effective readjustment may be accomplished so that the Society may take its proper place in the larger sphere of influence and usefulness now opening to the Profession.
>
> Such a survey and readjustment can be accomplished successfully only with the aid of the membership throughout the country.
>
> Any steps toward changes in organization must lead to a revision of the Constitution of the Society, which has not been materially modified for many years, during which the Society has grown rapidly and has established twenty-two local associations of members.
>
> The Constitution should be revised only after securing the views of the membership of the Society as to what its purposes and activities should be and as to the instrumentalities through which these purposes and activities should be carried out.
>
> Any changes in organization must take into account all the conditions above indicated, and also the relationship of the American Society of Civil Engineers to other engineering organizations and to the public.
>
> Therefore:
>
> *Resolved*, That a Committee be created to report on the purposes, field of work, scope of activity and usefulness, organization, and methods of work of the American Society of Civil Engineers, and to make recommendations concerning these matters; the Committee to consist of one member chosen by each Local Association of Members, and seven members at large appointed by the President.
>
> *Resolved*, That the President be instructed to select from this Committee an executive committee of not less than five nor more than nine members, and to appoint the chairman of this executive committee, who shall also be the chairman of the general committee.
>
> *Resolved*, That the President be instructed to prepare a precept for the general guidance of this committee.
>
> *Resolved*, That this Committee be requested to present to the Board of Direction a preliminary report, not later than November 1, 1918, so that it may be printed and distributed to the Membership in advance of the Annual Meeting in January, 1919, at which meeting it will be presented for discussion.

The canvass of ballots at the annual meeting resulted in the election of the following officers for 1919:

F. HERBERT SNOW, *President.*
HARRISON SOUDER, *Vice President.*
HENRY T. SHELLEY, *Secretary for two years.*
THOMAS EARLE, } *Directors for two years.*
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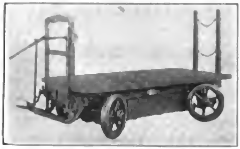

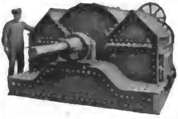

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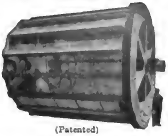

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